Doherty Memorial High School

299 Highland Street, Worcester, MA 01602

100% CD – Final Bid Package #4

Project Manual Volume III of IV – Div. 21-33

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Massachusetts School Building Authority (Project # 201603480512)
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PROJECT MANUAL AND SPECIFICATIONS

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DIVISION 13 – SPECIAL CONSTRUCTION

DIVISION 14 – CONVEYING EQUIPMENT

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DIVISION 21 – FIRE SUPPRESSION**

DIVISION 22 – PLUMBING**

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DIVISION 26 – ELECTRICAL**

DIVISION 33 – UTILITIES

VOLUME IV OF IV APPENDICES

End of Section

****Indicates Trade Sub-Bid Section bid at 100% CD Package.**

SECTION 21 00 01
FIRE PROTECTION (TRADE CONTRACT REQUIRED)

PART 1 GENERAL

PART 2 PRODUCTS

PART 3 EXECUTION

PART 1 GENERAL

1.1 GENERAL PROVISIONS – TRADE SUB-BID REQUIRED

A. Work of this Section requires Trade Sub-Bids and is governed by the provisions of the Massachusetts General Laws (MGL), Public Bidding Law Chapter 149A Section 8, Chapter 149 Section 44F, and applicable Section of the MGL, Public Contract Law Chapter 30 as amended.

1.2 RELATED DOCUMENTS

A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the documents identified in Division 00 Procurement and Contracting Requirements and Division 01 General Requirements.

1.3 SUMMARY

A. Section Includes:

1. Scope of work.

B. Related Sections include the following:

1. Section 01 91 13 "Commissioning Requirements – Building and Envelope."
2. Section 01 60 00 – Product Requirements:

3. Section 00 73 00 – EXECUTION for cutting of holes OVER 4" diameter or square and patching
4. Section 09 29 00 – GYPSUM BOARD for coordination with gypsum ceilings.
5. Section 09 51 00 ACOUSTICAL CEILINGS for coordination with acoustical ceilings.
6. Section 23 00 00 HEATING, VENTILATING AND AIR CONDITIONING for coordination with HVAC piping and ductwork.
7. All Sections of Division 26 00 00 - ELECTRICAL WORK for fire alarm devices.
8.

1.4 LEED V4 GENERAL REQUIREMENTS

A. The work of this Section is required to comply with general requirements and procedures for compliance with prerequisites and certain credits required for the Project to obtain Certified rating based on USGBC's LEED v4 Reference Guide for Building Design and Construction and as outlined in Division 01 Section "Sustainable Design Requirements."

B. The Construction Manager is responsible to coordinate with the work of other Sections and comply with all LEED v4 requirements in accordance with the Contract Documents such that the work carried out by this Section does not compromise the achievement of any other LEED v4 prerequisites and credits applicable to the entire Project.

C. Related Sections for Sustainable Design Requirements:

1. Section 01 25 13 “Product Substitution Procedures” for product substitutions.
2. Section 01 33 00 “Submittal Procedures” for LEED v4 submittal requirements.
3. Section 01 50 00 “Temporary Facilities and Controls” for requirements for temporary facilities.
4. Section 01 60 00 “Product Requirements” for additional LEED v4 submittal requirements.
5. Section 01 74 19 “Construction Waste Management” for waste management, recycling and disposal.
6. Section 01 81 13 “Sustainable Design Requirements” for general procedures for compliance with LEED v4 prerequisites and credits.
7. Section 01 81 19 “Indoor Air Quality Requirements” for material and procedure requirements.

1.5 PUBLICLY BID TRADE CONTRACTOR

A. The work of this section pertains to a Publicly Bid Trade Contract and includes the following requirements:

B. Submit bid as directed by and in compliance with the Invitation to Bid, Instructions to Bidders, and this Article 1.1.

C. Submit bid on the bid form provided in the Project Manual.

D. Submit bid in a sealed envelope in the manner described in the Instructions to Bidders before the date and time indicated for submission of bids.

E. The work to be completed by the Trade Contractor for the work of this Section is shown on the following listed Drawings, not just those pertaining particularly to this Trade Contract, unless specifically called out otherwise, regardless of where among the Drawings it appears:

F. The Work of this Trade Contract is shown on the following Drawings: FP1.0, FP 1.1 , FP 1.2, FP 1.3, FP1.4, FP4.1, FP 4.2, FP 4.3, FP 4.4, FP 4.5, FP4.6, FP4.7, FP4.8, FP4.9, FP4.10, FP4.11, FP4.12, FP4.13, FP4.14, FP4.15, FP4.16, FP4.17, FP4.18, S1.03, A7.1, A7.2, A7.3, A7.4, A7.5, A7.6, A7.7, A7.8, A7.9, A7.10, A7.11, A7.12, A7.13,

G. Related items which may require coordination or impact work of this trade are shown on the following Drawings: P2.1, P2.2, P2.3, P2.4, P3.1, P3.2, P3.3, P3.4, P3.5, P3.6, P3.7, P3.8, P3.9, P3.10, P3.11, P3.12, P3.13, P3.14, P3.15, P3.16, P3.17, P3.18, P3.19, P3.20, P3.21, P4.1, P4.2, P4.3, P4.4, P4.5, P4.6, P4.7, P4.8, P4.9, P4.10, P4.11, H3.1, H3.2, H3.3, H3.4, H3.5, H3.6, H3.7, H3.8, H3.9, H3.10, H3.11, H3.12, H3.13, H3.14, H3.15, H3.16, H3.17, H3.18, H3.19, H3.20, H3.21, H3.22, H4.1, H4.2, H4.3, H4.4, H4.5, H4.6, H4.7, H4.8, H4.9, H4.10, H4.11, H4.12, H4.13, H4.14, H4.15, H4.16, H4.17, H4.18, H5.1, H5.2, H5.3, H5.4, H5.5, H5.6, H6.1, H6.2, H6.3, H6.4, H6.5, H6.6, H7.1, H7.2, H7.3, H7.4, H7.5, H7.6, H7.7, AV1.0, AV1.1, AV1.2, AV3.3, AV3.4, AV3.6, AV3.8, AV3.10, AV3.14, AV3.20, AV4.1, AV6.1, AV6.2, AV6.3, AV7.1, AV7.2, AV7.3, AV8.0, AV8.1, AV8.2, AV8.3, AV8.4, AV8.5, AV8.6, TL3.4, TL3.12, TL3.20, TL4.1, TL4.2, TL6.1, TL6.2, TL9.0, TL9.1, TL9.2, TL9.3, TP1, TR3.4, TR3.12, TR4.1, TR5.10, TR6.1, E0.1, E0.2, E0.3, E0.4, E0.5, E0.6, E0.7, E0.8, E0.9, E0.10A,

E0.10B, E0.11, E0.12, E1.1, E1.2, E1.3, E1.4, E1.5, E1.6, E1.7, E1.8, E1.9, E1.10, E1.11, E1.12, E1.13, E1.14, E1.15, E1.16, E1.17, E1.18, E1.19, E2.1, E2.2, E2.3, E2.4, E2.5, E2.6, E2.6A, E2.6B, E2.6C, E2.7, E2.8, E2.9, E2.10, E2.11, E2.12, E2.13, E2.14, E2.15, E2.16, E2.17, E2.18, E3.1, E3.2, E3.3, E3.4, E3.5, E3.6, E3.7, E3.8, E3.9, E3.10, E3.11, E3.12, E3.13, E3.14, E3.15, E3.16, E3.17, E3.18, E3.19, E3.20, E4.0, E4.1, E4.2, E4.3, E4.4, E4.5, E4.6, E4.7, E4.8, E5.0A, E5.0B, E5.0C, E5.0D, E5.0E, E5.0F, E5.0G, E5.0H, E5.01, E6.0A, E6.0B, E6.0C, E6.0D, E6.0E, E9.00, E9.01, E9.02, E9.03, E9.04, E9.05, E9.06, E9.07, E9.08, E9.09, E9.10, E9.11, E9.12, E9.13, E9.14, E9.15, E9.16, E9.17, E9.18, E9.19, E9.20, E9.21, FA1.1, FA1.2, FA1.3, FA1.4, FA1.5, FA1.6, FA1.7, FA1.8, FA1.9, FA1.10, FA1.11, FA1.12, FA1.13, FA1.14, FA1.15, FA1.16, FA1.17, FA2.1A, FA2.1B, FA2.1C, FA2.1D, FA2.1E, FA2.2, FA2.2B, FA2.3, TC1.1, TC1.2, TC1.3, TC1.4, TC1.5, TC1.6, TC1.7, TC1.8, TC1.9, TC1.10, TC1.11, TC1.12, TC1.13, TC1.14, TC1.15, TC1.16, TC1.17, TC1.18, TC2.1, TC2.2, TC2.3, TC2.4, TC2.5, TC2.6, TC3.1A, TC3.1B, TC3.1C, TC3.2A, TC3.2B, TC3.2C, TC3.2D, TC3.3A, TC3.3B, TC3.3C, TC3.4A, TC3.4B, TC3.4C, TC3.5A, TC3.5B, TC3.6, TC3.7A, TC3.7B, TC3.8A, TC3.8B, TC3.8C, TC3.8D, PV001, PV002, PV101, PV102, PV103, PV104, PV201, PV301, PV302, PV501, PV502, PV503, PV601, PV602, PV603, PV604, PV605.

H. The complete List of Drawings for the Project is provided in Section 00 01 15 – List of Drawings.

I. The Trade Contractor shall perform the complete trade work, including the following listed sub-trade classes of work, with employees on its own payroll unless the Trade Contractor identifies on the bid form, the name of a sub-sub-contractor that will perform each of the following classes of sub-trade work and the corresponding sub-trade subcontract sum. This Section of the Specifications requires that the following classes of work shall be listed in Paragraph E under the conditions indicated herein.

1. None

J. If the Trade Contractor intends to use sub-trade subcontractors to perform any portion of the trade work other than the customary sub-trade classes of work listed in Paragraph 1.5 (J), above, the Trade Contractor shall list on the bid form the names of each such sub-trade subcontractor and each respective sub-trade subcontract sum unless: (a) the value of the sub-trade subcontract is less than Ten Thousand Dollars ($10,000), or (b) the sub-trade subcontract is not subject to the provisions of MGL c. 149, §§ 44A-J.

1.6 DESCRIPTION OF WORK

A. Commissioning: The FP system will be commissioned by an independent commissioning agent (CxA). The Fire Protection Trade-contractor shall review all commissioning requirements outlined in Sections 01 91 13 (Commissioning Requirements – Building and Envelope), and shall provide all commissioning task labor and documentation, attend all required meetings, and provide all on-site assistance required by the CxA to properly complete their work.

B. Alternates: Special attention is called to the fact that it shall be the responsibility of all the General and Trade-contractors to thoroughly examine all the alternates and evaluate for themselves as to whether or not these alternates in any way affect their respective section. In the event that a Contractor feels that any alternate(s) do reflect a cost difference, additional or a deduction in his bid proposal, then he shall so stipulate

this sum and/or sums under the proper alternate(s) as provided for the bid proposals. Failure to do so will in no way relieve the hereinbefore stated contractors of their responsibilities regardless of what alternate(s) are selected and no extra cost shall be charged to the Owner. Refer to Section 01 23 00, ALTERNATES for the list and description of Alternates.

C. Work Included: Provide labor, materials and equipment necessary to complete the work of this Section, including but not limited to the following:

D. New flow test, witnessed by the design Engineer-of-Record and / or local Fire Department..

1. The flow test shall be performed in accordance with the recommendations of NFPA 291.

2. The flow test shall be performed during a period of “ordinary demand” – occurring between 9-5 pm on a week-day,

3. Flow a sufficient number of 2-1/2” outlets / hydrants, to flow the fire-flow demand, ***or*** provide a residual pressure 75% of the static pressure.

4. Gages:

a. Gage hydrant gage shall be a 0-200 psi gage, with 2 psi increments.

b. Flow hydrant pitot gages shall be 0-50 or 0-60 psi, with 1 psi increments.

c. Gauges shall be accurate to +/- 1.5% of full scale.

d. Use only gages calibrated within the last 12 months, and bearing the sticker of the calibrating agency.

e. Avoid pitot pressure less than 10 or over 30 psi, by flowing more or fewer outlets.

a. Provide a detailed report approved by the Engineer of Record. Report shall – include:

a. a cover sheet with the contractors contact info, time and date of test,

b. a to-scale sketch showing the location and elevation of all flow and pressure hydrants,

c. the location and number of outlets flowed, with actual pitot readings, as well as translated flow and pressure results.

d. Copies of gage calibration reports

E. New “Sprinkler Valve and Water-flow detector” display panels – required by 780 CMR section 911 for fire command centers in high-rise buildings.

F. Prepare "Fire Protection Shop Drawings" and hydraulic calculations, stamped by a Mass. Professional Registered Engineer. The City of Worcester has obtained a variance permitting the code-required Fire Pump to be omitted. Thus, no Fire Pumps will be permitted to be used in the shop drawings without written permission from the Owner's Project Manager.

1. Shop drawings shall show the same portions of the building on each sheet as the bid set drawings, and each sheet shall include a blocked-out key-plan – showing what portion of the building is shown on that sheet.

2. Shop drawings shall include the entire scope of work shown or specified in the bid documents, including (but not limited to):

   a. Air and water sealing of all exterior wall penetrations,
   b. Required hanger locations in addition to max. on center spacing.
   c. Special roof hydrant options requested by WFD, and shown in the drawing detail.
   d. Height of all drains outside the building
   e. Flex-connector FM requirements
   f. Branch restraint options that will be used anywhere in the building.

3. Shop drawings shall include the following design criteria.

   a. Name of Owner
   b. Address of location
   c. Point of compass
   d. Full-height section if included in the bid set, or required for clarity
   e. Location of partitions
   f. Location of fire walls
   g. Occupancy / hazard of each room / space
   h. Location of concealed spaces, closets, attics, and bathrooms
   i. Locations where sprinklers are omitted.
   j. Size of city main in street, and whether dead-end or circulating. If dead end, direction and distance to nearest circulating main.
   k. City main flow test results, and elevation of sprinkler system relative to test gage hydrant.
   l. Make, type, model and K-factor of all sprinklers, including SIN numbers Temperature rating, and location of high temperature sprinklers.
   m. Total area protected by each system on each floor
   n. Number of sprinklers on each riser per floor
   o. Pipe type and wall-thickness schedule
   p. Nominal pipe size and lengths (or center to center distances)
   q. Location and size of riser nipples
   r. Types of fittings and joints, and the location of all welds.
   s. Type and location of hangers, sleeves, and braces
   t. All control valves, check valves, drains, and test connections
   u. Make, model and size of alarm
   v. Kind and location of alarm bells
   w. Flushing provisions
   x. Hydraulic calculation data
   y. A graphic representation of the drawing scale.
   z. Name and address of contractor
   aa. Hydraulic reference points shown on the drawings, corresponding to

reference points used in the calculations

bb. The minimum rate of water application, design area of water applications, and hose streams (inside and outside)
cc. The total water flow and pressure required at the flow-test gauge hydrant for each system.
dd. Relative elevation of sprinklers, junctions, and reference points.
ee. If room design method is used, all unprotected wall openings throughout the floor.
ff. Sizing calculations and details of sway bracing.
gg. Manufacturer, size, and type of backflow preventor.
hh. Size and location of site and flow-test hydrants, including size and number of hydrant outlets, outlet valves, and hose houses (If any).
ii. Size, location, and piping arrangement of FDCs
jj. Ceiling / roof heights and slopes not shown in the full-height section.
kk. Edition year of NFPA 13 to which the system was designed.

4. Complete and operating combination sprinkler and standpipe system and all required accessories per NFPA 13, 2013, and NFPA 14, 2013 edition, with 4 combination sprinkler standpipe risers, 4 standpipe-only risers, and all inter-connecting piping, riser isolation valves, roof hydrants / hose valves, and drains.

   a. Roof hydrants shall include all features shown on the detail, FP1.4 / 2.
   b. Roof hydrants have been waived by WFD in locations that can be covered by a 150' hose from a nearby roof hydrant. See key plan for details.

5. 2 New, 6", Fire Dept. Connections with 4, 2-1/2" inlets each, approved by the Worcester Fire Dept. Pipe FDC ball drips to the exterior of the building. terminating with a 45 down FDCs shall include all inter-connecting piping required to serve all risers, plus 2 stage hose stations.

6. Provide a supervised control valve and flow switch on the line to the stage hose stations

7. New electric bell and blue beacon, mounted above the FDC (per the architectural elevations). Shall activate upon any fire alarm or sprinkler water-flow.

8. Provide temporary standpipe hose stations on each floor as the building is erected per NPFA 241. Permanent-standpipe risers may be used as the temporary standpipe. Maintain temporary hose stations in service until the standpipe-sprinkler system is substantially complete.

9. Complete and operating wet sprinkler system (most of building) and dry sprinkler system (under-building parking garage)per NFPA 13 2013 edition, the 9th Edition State Building Code, local ordinances, and the pre-approved Fire Protection Narrative.

10. New zone-control-valve (ZCV) stations, each with check valve, pressure-relief valve, control valve. supervised tamper switch, supervised flow switch, and valved pressure gages located on each floor for all sprinkler / standpipe risers serving more than 1 floor.

11. Complete and operating clean-agent fire suppression system for the 563 sqft IT

Server Room, per NFPA 2001. Clean agent system shall include all design, materials, and installation including: including charged Novec 1230 storage tank(s), nozzles, control panel, detectors, pull station, abort station, wiring, annunciators, alarm and all other equipment necessary for a complete operational system. Design and installation shall be by a factory-certified and licensed distributor of the system manufacturer.

12. Supervise the installation and pressure testing of all underground water piping and valves dedicated to Fire Protection service. Provide a completed, NFPA Materials and Test certificate for the underground FP-only piping.

13. The Fire Protection Trade-contractor's installation scope responsibility shall start at a blank flange, inside the FP-service room, at the termination of the site-contractor's new 8" FP water entrance..

14. New 8" backflow preventor. Backflow to include full-port, line-size, indicating control valves on either side and a valved pressure gauge on the city side.

15. Approved Seismic separation assembly providing 1" of movement in all directions, wherever FP piping crosses a building seismic separation joint. Provide a 4-way brace within 6', on both sides of each seismic separation assembly.

16. Main drain piping (size per NFPA) and auxiliary drains per NFPA 13 for complete draining of all new piping. Pipe main drains to the exterior of the building as shown. Alternate drain terminations proposed by the contractor must be explicitly approved in writing by the Architect and the Engineer of record. Auxiliary drains shall be clearly labeled in the field, and noted clearly on the as-built drawings – see record drawing requirements.

17. Sprinkler heads per the sprinkler legend. Include sprinkler guards where specified.

18. Piping mains, cross mains, and branches, fittings and valves, flexible connectors, and expansion fittings. Include swing arms to center sprinklers in tiled ceilings.

19. New inspector's test-tees – one at each ZCV station.

20. New identification signs at all new control valves, Fire Dept connections, standpipe connections, test & drains, auxiliary drain valves, and sprinkler valve room.

    a. Valve signs shall indicate their function and normal position.

    b. All signs shall meet the 9th Edition State Building Code requirements), as well as NFPA 13, 2013 requirements.

21. Hangers and supports, sleeves, and escutcheons, including miscellaneous steel supports.

    a. Hanger spacing per the drawing schedule, which per the structural engineer's direction is more stringent than NFPA 13.
    b. Additional hangers required beyond minimum o.c. spacing include: within 2' of all changes in direction, within 2', on both sides of concentrated loads.

22. Access panels for any devices or equipment installed in other-wise inaccessible locations (none required for bid-set layout)

23. Seismic bracing on all risers, mains, cross mains, and all branches 2-1/2" and over, installed per the drawing details and NFPA 13, Seismic restraint on all branches 2" and under, installed per the drawing details and NFPA 13,. All seismic braces shall attach to steel structure – attachment to decks is prohibited.

24. Drilling for installation of hanger and sway-bracing inserts.

25. Core drilling and cutting and patching for the Work of this Section per section 01 73 00.

26. 6 spare sprinklers of each type, along with sprinkler wrenches in 1 or more labeled spare sprinkler cabinet(s) located in the water room.

    a. Provide also – 10, additional sprinklers, up to 60 LF of 1" pipe for swing-arms, 10, 1" hangers, flex connectors (if used), and all design, project managements, shop labor, and installation labor for 10 additional sprinklers. These sprinklers are not shown and shall be used in unspecified locations as required.

27. All tamper and alarm switches to be monitored by the Fire Alarm Control Panel provided by Division 26 00 00.

28. Shop drawings and submittals, coordination and record drawings. See Division 1 for coordination drawing requirements.

29. Hoisting Equipment: This trade contractor shall furnish, install and maintain in safe and adequate condition all mechanical hoisting equipment, rigging equipment, crane services, lift machinery, and operating personnel that are necessary for the proper execution of the Work of this Section, as referenced under Section 015000 - Temporary Facilities and Controls.

30. Staging, Planking and Scaffolding: This trade contractor shall obtain required permits for, and furnish, install, maintain in safe and adequate condition, and dismantle when no longer required, all staging, planking, scaffolding, portable ladders and mobile platforms, and tarpaulins for covering same that are necessary for the proper execution of the Work in this Section.

31. Temporary enclosures and heat are specified in Section 01 50 00.

32. Fire-stopping of all rated wall, floor, and ceiling penetrations used by the Fire Protection Trade-contractor for any work completed under this Section. See section 07 84 00 Firestopping for required methods and procedures.

33. Walls requiring sound-seal, noted with STC-rating, including but not limited to: Classrooms, offices, media center, cafeteria, gymnasium, music rooms, and bathrooms (for sound control), and thru exterior walls (for water and air seal) to be sealed with non-combustible, water-proof material, as specified in section 09 29 00 Gypsum Board, both sides of all penetrations

34. System flushing, and 2 hour hydrostatic and 24 hour air pressure tests on all new

piping, per NFPA 13. Tests shall be witnessed by the Engineer of record, Owner's Project Manager, or Worcester Fire Dept. Repair all defects.

35. System and equipment start-ups, and completed NFPA 13 test and acceptance reports . Repair all defects.

36. Assist Fire Alarm trade contractor in the testing of all FP flow switches, pressure switches, pre-action system panel and devices, flow alarms and tamper switches, and clean agent panel and controls. Submit signed off test report – see list of devices requiring testing under section 3.17.

    a. Successful F/A testing of all FP devices listed in section 3.17 is a pre-requisite to FP substantial completion.
    b. F/A testing of all FP devices listed in section 3.17 shall be repeated 1 year after substantial completion. Successful testing is a pre-requisite to ending the warranty period.

37. Pull all permits, pay all fees and obtain required inspections. Worcester building department permit application fees have waived by the City.

38. Refer to Division 1, particularly Sections 01 77 00 and 01 78 00 for Close-out document requirements. FP Close-out documents shall include at minimum::

    a. As-built drawings and approved, record calculations.
    b. Operation and Maintenance Manuals
    c. Video-taped Instructions to Owners personnel, covering all specified topics.
    d. Color-coded, full-size, protected and permanently mounted floor plans at the main entrance by each FDC, showing all FP zones, and locations of zone control valves.
    e. Color-coded, 8x11 floor plans at each zone control valve station, showing the area served by that control valve
    f. completed NFPA 13, 14, and 20 test and acceptance reports for all above-ground FP systems,
    g. completed NFPA 13 test and acceptance report for underground, FP-only piping.
    h. Completed NFPA 13 General Information Sign
    i. Typed, NFPA 13 spare sprinkler list in each spare sprinkler cabinet.
    j. 1 year written warranty – starting as substantial completion.

39. Site Visit:

    a. Bidders are expected to examine and to be thoroughly familiar with all contract documents and with the conditions under which work will be carried out. The Awarding Authority (Owner) will not be responsible for errors, omissions and/or charges for extra work arising from General Contractor or Trade contractor's failure to familiarize themselves with the Contract Documents or existing conditions.

    b. By submitting a bid, the Bidder agrees and warrants that he has had the opportunity to examine the site and the Contract Documents, that he is familiar with the conditions and requirements of both and where they require, in any part of the work a given result to be produced, that the Contract Documents are adequate and that he shall produce the required results.

40. Alternates: Not Applicable.

41. Items to be Installed Only: Not Applicable.

42. Items to Be Furnished Only: Furnish the following items for installation by the designated Sections:

    a. Section 03 30 00 – CAST-IN-PLACE CONCRETE:
        i. Galvanized, schedule-40-sleeves, anchors, inserts, plates and similar items for fire protection systems.

    b. Section 04 20 00 – UNIT MASONRY:
        i. Access doors in masonry openings.
        ii. Schedule 40, galvanized-steel Sleeves at fire-wall.

    c. Section 09 29 00 - GYPSUM BOARD:
    d. Access doors in gypsum board assemblies.

1.7 QUALITY ASSURANCE

A. References to manufacturers and to catalog designations, are intended to establish standards of quality for materials and performance but imply no further limitation of competitive bidding.

B. If Drawings or Specifications do not coincide with manufacturers' recommendations, alert Designer in writing before installation and request clarification.

C. All MEP work shall comply with all applicable Federal, State, and Local codes and standards and other authorities that have legal jurisdiction over the site.

D. If provisions of the Contract Documents conflict with any code, rule, or regulation, the latter shall govern.

E. Where the Contract requirements are in excess of applicable codes, rules or regulations, the Contract provisions shall govern.

F. Standards and References to be followed include:

1. 780 CMR Massachusetts State Building Code – 10th Edition,
2. International Code Council (ICC) International Mechanical Code (IMC) - 2015
3. National Fire Protection Association (NFPA) 13 (2013), 14 (2013), 25 (2014), 241 (2009).
4. NFPA 2001: Standard on Clean Agent Fire Extinguishing Systems 2015
5. NFPA 72 – National Fire Alarm and Signaling Code
6. NFPA 75: Standard for the Fire Protection of Information Technology Equipment NFPA 76: Standard for the Fire Protection of Telecommunications Facilities
7. 527 CMR 1 Massachusetts Comprehensive Fire Safety Code
8. Occupational Safety and Health Act (OSHA).
9. Factory Mutual Association (FM).
10. NFPA 70 (National Electric Code - NEC).(2019)
11. National Electrical Manufacturers Association (NEMA).
12. Environmental Protection Agency (EPA).

13. Commonwealth of Massachusetts Department of Environmental Protection (DEP).
14. Local Ordinances, Regulations of City of Worcester
15. American National Standards Institute (ANSI).
16. American Society of Mechanical Engineers (ASME).
17. American Society for Testing and Materials (ASTM).
18. Underwriters' Laboratories, Inc. (UL).
19. American Insurance Association (A.I.A.) (formerly National Board of Fire Underwriters).

20. Modification of references: In each of the above listed codes, the Fire Protection Trade-Contractor shall consider the advisory provisions to be mandatory, i.e. substitute the word "shall" for "should" wherever it appears.

21. The Clean Agent System shall be designed and installed in strict conformance with the Manufacturer's Design, Installation, Operation and Maintenance Manual

22. Installer Qualifications: Installations, repair, and servicing of equipment, piping, or accessories shall be performed only by qualified installers. The term "Qualified" means:

    a. Journey-man's license in the trade
    b. has worked on a minimum of 1 previous projects similar in size and scope to this project;
    c. reads and follows the manufacturer's installation instructions;
    d. is familiar with all safety precautions required; and
    e. complies with all code and local Authority requirements.

    f. Upon request, submit evidence of such qualifications to the Engineer.

23. The Fire Protection Trade-Contractor shall obtain all permits and arrange for all required inspections. Additional inspections required due to work not meeting the AHJ's requirements shall be paid for by the Fire Protection Trade-Contractor. The Fire Protection Trade-Contractor shall comply with all Local Code Enforcement Officials' instructions ..

1.8 MATERIAL AND SUBSTITUTIONS

A. The design is based on the equipment listed in the drawing schedules and specifications. Equipment from other manufacturers can be substituted provided where all of the following are met.

B. Finish of materials, components and equipment shall be approved by the Architect and shall be resistant to corrosion and weather as necessary.

    1. Where materials are available in more than 1 standard factory color, all color selections shall be made by the Architect, from the full range of available colors.

C. Substituted materials are equal or superior in performance and construction, "Construction" includes but is not limited to: type, quality, and thickness of materials; type and quality of paint finish; type and quality of electrical connections, controls and motors; and electrical or combustion efficiency.

1. the proposed- equipment submittals are approved by the engineer.

2. If the Fire Protection Trade-Contractor chooses to provide substitute equipment, he shall provide shop drawings, stamped by a registered engineer, for any system re-design required to accommodate the alternate equipment. Stamped shop drawings must be approved in writing by the Engineer-of-record prior to the start of construction.

1.9 SUBMITTALS - PRODUCT

A. Refer to Division I for details on submittal format and number of copies required. In addition to the Division 1 requirements – submit a full-size paper set for each required shop drawing submittal (by phase) and re-submittal, mailed to the Engineer of Record at PO Box 905, Brattleboro, VT 05302.

B. Within 30 days after the notice to proceed, and before purchasing any materials or equipment, provide all required product submittals along with the respective suppliers name, phone number, and email address.

C. Obtain detailed manufacturer's installation instructions for all equipment provided under this Section, and include in the equipment submittal.

D. Product data on standard manufactured items shall include:

1. an illustration of the item to be furnished,
2. performance curves and charts,
3. electrical requirements.
4. efficiency ratings
5. details, size dimensions,
6. Cut sheets shall be clearly marked as to what model, options, and accessories are being proposed.
7. Warranty for each item.
8. Operation and maintenance instructions for each item

E. Prior to submission, the Fire Protection Trade-Contractor shall review each submittal, and certify in writing that it complies with the contract documents in all respects. Uncertified submittals will not be reviewed, and re-submission shall be required.

1. Product submittals shall be submitted a minimum of 3 weeks before the start of the respective work. The Fire Protection Trade-Contractor shall allow for this time period in scheduling his work, and no claim for delay will be granted for failure to comply with this requirement. Comply with requirements specified in Section 01 33 00 – SUBMITTAL PROCEDURES.

F. Material and equipment requiring Submittals shall include but not be limited to:

1. Control Valves.
2. Double check-valve, backflow preventor
3. Fire Dept. connections – Sprinkler / Standpipe
4. FDC check valves and ball drip
5. Roof hydrants / PIVs
6. Fire department hose valves.
7. Sprinkler zone-control-valve-station valves and manifolds.

8. Drain and test connections
9. Pressure relief valves
10. Vane type Flow switches (wet system)
11. Pressure-type flow switches (dry system)
12. Pressure type supervisory switches
13. Tamper switches
14. Pressure gages
15. Pressure switches
16. Dry valve, quick opening devices, and trim
17. Air compressor, check valves, and air-maintenance devices
18. Clean-agent IT Server suppression system: Including Detectors, Manual discharge switches, Control panel, Release devices, Alarm devices, Agent storage cylinders, Mounting brackets, Discharge nozzles, Abort stations, Piping isometrics, Flow calculations
19. Auto Drain valves
20. Wet Sprinkler heads (each type, K-factor, and temperature rating used).
21. Dry Sprinkler heads (each type, K-factor, and temperature rating used).
22. Pipe, fittings, and flexible connectors.
23. Hangers and supports.
24. Seismic bracing, restraints, and attachments.
25. Auxiliary drain valves including dry drains.
26. ID signs, pipe labels, valve tags, hydraulics signs, and general information sign
27. Fire-stopping and sound-sealing materials
28. Exterior wall air-water sealing materials
29. Escutcheons and wall-plates

G. Other submittals required:

1. Wet and Dry system Shop drawings and calculations (see paragraph 1.19 for more details).

2. Clean Agent System Shop drawings and calculations including
   a. piping floor plan and isometric diagram,
   b. point-to-point wiring diagrams,
   c. Riser diagram showing connections to all monitor and control functions.
   d. storage tank sizing calculations, and agent flow calculations.
   e. Sequence of operations,
   f. Testing plan including means, methods, and schedule for testing the interface with fire alarm monitoring and alarm functions.

3. Monthly requisitions for work completed and approved

   a. Submittals, Shop drawings and calculation requisitions will be approved to a maximum of 80% until the submittals are approved

   b. Piping Rough-in without bracing, restraints, sleeves, and fire-stopping / sound-sealing will be approved to a maximum of 70% .

   c. Piping Rough-in with bracing, restraints, sleeves, and fire-stopping / sound-sealing will be approved to a maximum of 85%

4. Coordination drawings

5. Signed off punch lists when work is ready for re-inspection.

6. Minimum 1 week notice to the Engineer of Record of scheduled tests including:

   a. flow test,
   b. backflow preventor forward-flow test, and main drain test
   c. underground piping pressure testing and flushing, and
   d. above-ground pressure testing and flushing.

7. Minimum 1 week notice to the Engineer of Record of scheduled device acceptance testing date and time. (Engineer to witness).

8. Signed off backflow preventor permit and inspection report.

9. NFPA 13 test and acceptance reports and certificates, signed by the AHJ.

   a. All pressure testing and flushing reports shall be submitted to the Engineer of Record for review within 2 weeks of the test.
   b. Reports shall be re-submitted as a package as part of the close-out documents.

10. Complete and accurate as-built drawings and record calculations.

11. Where the number of field-added-elbows exceeds 6 for any calculation, those elbows shall be added to the design calculation, and the revised calculation submitted for record.

1.10 CONTRACT DOCUMENTS

A. Drawings and Specifications are complementary to each other. Provide work specified and not shown, and work shown and not specified as though explicitly required by both.

B. Unless specifically noted otherwise, the indication and/or description of any item, in the drawings or specifications or both, carries with it the instruction to furnish and install the item.

C. Drawings are diagrammatic. They indicate general arrangements of equipment, systems and other work. They do not show all offsets required for coordination nor do they show the exact routings and locations needed to coordinate with structure and other trades and to meet Architectural requirements. The purpose of the drawings is to indicate a systems concept, the main components of the systems, and the approximate geometrical relationships. Based on the systems concept, the main components, and the approximate geometrical relationships, the Fire Protection Trade-contractor shall provide all other components and materials necessary to make the systems fully complete and operational.

D. Data that may be furnished electronically by the Designer (on computer tape, diskette, or otherwise) is also diagrammatic. If furnished, such data is for convenience and generalized reference.

E. Information and components shown on riser diagrams but not shown on plans, and vice versa, shall apply or be provided as if expressly required on both.

1.11 DISCREPANCIES IN DOCUMENTS

A. Any inconsistencies, omissions, or conflicts shown on the FP plans shall be brought to the Engineer's attention for clarification.

B. Where conflicts or potential conflicts exist and engineering guidance is desired, submit a sketch of the problem to the Designer for review and direction.

C. If the required material, installation, or work can be interpreted differently from drawing to drawing, or between drawings and specs, request clarification, *or* provide that material, installation, or work which is of the higher standard.

D. Prior to installation of visible material and equipment, including access panels and drains, field coordinate the exact locations with the Architect.

1.12 PROTECTION

A. At all times, protect all building structures, equipment and systems not designated for demolition.

B. Each Trade-contractor shall be held responsible for any injuries or damage done to the building premises, adjoining property, or to other Contractors' work resulting from the execution of his part of the work.

C. In case of dispute arising over the responsibility incurred by each Trade-contractor, it is agreed between the Owner and each Trade-contractor that such liability and extent of damage shall be determined by the Engineer, whose decision shall be final and binding on all parties.

D. Owner will not be responsible for any material or equipment before testing and acceptance.

1.13 COORDINATION

A. Check other trades Contract Drawings, shop drawings and approved submittals, and coordinate work with all other trades affecting, or affected by work of this section. Cooperate with such trades to assure the steady progress of all work under the Contract.

B. The Fire Protection Trade-Contractor shall furnish all information pertaining to his materials as to sizes, locations, means of support, to all other trades requiring such information.

C. Ensure that access openings leading to equipment are large enough to carry through routine maintenance items such as tools

D. Make reasonable modifications in layout and components needed to coordinate and prevent conflict with the work of other trades. Additional piping offsets required to coordinate with other trades shall be made with 45 degree bends wherever possible. Required offsets that cannot be made with 45 degree bends must be reviewed and approved in writing by the Engineer of record on a case-by-case basis.

E. The Fire Protection Trade-Contractor shall, at all times, have a foreman on the project authorized to make decisions, coordinate work, and receive instructions. Once construction has begun, the foreman shall not be removed or replaced without the express approval of the Engineer.

F. Each Trade-contractor, at his own expense, shall relocate all uncoordinated installations if they interfere with the proper installation and mounting of other trades work, including hung ceilings, architectural design features, and structural finish.

G. See Division 1 for other Coordination Drawing Requirements. Coordination Drawings include but are not necessarily limited to:

1. Structure.
2. Partition/room layout.
3. Ceiling tile and grid.
4. Light fixtures.
5. Access panels.
6. Sheet metal, heating coils, boxes, grilles, and diffusers.
7. All heating piping and valves.
8. Smoke and fire dampers.
9. Soil, waste and vent piping.
10. Major water and medical gases.
11. Roof drain piping.
12. Major electrical conduit runs, panel-boards, feeder conduit and racks of branch conduit.
13. Above ceiling miscellaneous metal.
14. Sprinkler piping and heads.
15. Heat tracing of piping.

1.14 GUARANTEE AND 24 HOUR SERVICE

A. Guarantee Work of this Section in writing for one year following the date of beneficial occupancy by the User Agency. Warranty letter shall summarize specifically what is included:

1. 24-hour service, - with phone number that will be answered 24-hrs.
2. Repair or replacement of any defective materials, equipment, or workmanship.
3. Replacement of any equipment requiring excessive service (as defined by OPM)
4. Manufacturer’s engineering on-site support for any problems not readily solved.

B. The guarantee shall repair or replace defective materials, equipment, workmanship and installation that develop within this period, promptly and to Designer's satisfaction and correct damage caused in making necessary repairs and replacements under guarantee within Contract Price.

C. Use of systems provided under this Section for temporary services and facilities shall not constitute Final Acceptance of work nor beneficial use by User Agency, and shall not institute the guarantee period.

D. If the equipment is used for temporary service prior to substantial completion, the bid price shall include an extended period of warranty covering the one-year of occupancy, starting from the initial date of beneficial occupancy by the User Agency.

E. Provide 24 hour service beginning on the date the project is first beneficially occupied by the User Agency, whether or not fully occupied, and lasting until the termination of the guarantee period. Service shall be at no cost to the Owner. Warranty letter shall include a phone number that will be answered on a 24-hour basis each day of the week, for the duration of the 24-hour-service.

F. Service can be provided by the Fire Protection Trade-contractor or a separate service organization. Choice of service organization shall be subject to Designer and Owner's Project Manager approval.

G. Replace material and equipment that require excessive service during the guarantee period. "Excessive" shall be as defined by the Designer, and may vary by equipment type.

H. At the end of the guarantee period, transfer manufacturers' equipment and material warranties still in force to User Agency. Submit copies of all equipment and material warranties to Designer before final payment.

I. This Paragraph shall not be interpreted to limit Owner's Project Manager's rights under applicable codes and laws or under this Contract.

J. Part 2 Paragraphs of this Specification may specify warranty requirements that exceed those of this Paragraph.

K. If warranty problems cannot be rectified immediately to Owner's Project Manager's satisfaction, immediately provide manufacturer's engineering and technical staff at site to analyze and rectify problems. Advise Designer in writing, describe efforts to rectify situation, and provide analysis of cause of problem. Follow Designer's instructions.

1.15 RECORD DRAWINGS

A. The Record drawing set shall include a complete set of bid-set drawings plus all of the Fire Protection Trade-contractor's final-approved, shop drawings, plus all SKs issued by the design team.

B. Record documents shall also include a final, approved set of hydraulic calculations, with all submittal-phase comments addressed.

C. Color coded, laminated and framed, full-size plans, showing the location of each riser and each zone-control-valve station.

1. Each control valve's service area shall be colored in a different, distinct color.
2. Permanently mount 1 plan in each lobby containing a Fire Alarm annunciator.
3. Control valve locations shall be high-lighted in yellow, with large-font call-outs pointing to the exact valve location, and stating the zone number.

D. The Fire Protection Trade-Contractor shall keep a hard copy of contract drawings at the site and mark any changes to drawings as changes are made. Record documents shall reflect all changes from the Contract Drawings, whether by approved submittal, Change Order, or by field conditions. As-built drawings shall also indicate existing conditions different from those shown.

E. Clearly Mark with minimum 4 point red cloud filled with yellow high-lighter, the location of all control valves, riser valves, pressure gages, flow switches, tamper switches, main and auxiliary low-point drains, and spare sprinkler storage. Mark with yellow high-lighter, the text call-outs that identify the clouded-highlighted devices.

F. Drawings shall show record condition of details, sections, riser diagrams, control changes and corrections to schedules. Schedules shall show actual manufacturer and make and model numbers of final equipment installation.

G. At the project completion, as-built drawings shall be submitted per Division I requirements. Availability of marked-up “As-built” drawings shall be a prerequisite to scheduling Final Inspection of this Contract.

H. Inaccuracies in the marked-up "As-Built" Drawings shall be grounds for holding retainage until the discrepancies have been corrected.

I. After all of the Engineer’s comments are addressed, the Fire Protection Trade-Contractor shall submit final set(s) of reproducible or electronic As-built drawings to the Engineer.

1.16 MAINTENANCE MANUALS

A. Before final payment, the Fire Protection Trade-Contractor shall furnish to the Owner 1 PDF copy, and three, labeled, hard-cover, 3-ring binders each containing a complete set of the information described below. Inscribe on the cover:

B. “Operation and Maintenance Manual”, the name and location of the project, the name of the Fire Protection Trade-Contractor and the contract number

C. The manual shall have a typed Table of Contents (bookmarks in the PDF version) with tab sheets placed before each section.

D. List of names, addresses, and phone numbers of all sub-contractors as well as the local representative for each item of equipment.

E. Each Manual shall include the following information:

1. Copy of all submitted and “received for record”, final NFPA 13 material and test certificates.

   a. All forms shall be current, standard, NFPA 13 forms

   b. Include an Above-ground certificate for each riser.

   c. Include an Underground certificate for the FP-only feed into the building – installation, pressure testing, and flushing must all be supervised by the licensed FP trade-contractor..

   d. On each test certificate, individually list every alarm and tamper device to be tested, and initial each one as it is tested and passes. Use “attached sheets” if required.

   e. Test every alarm device and tamper device with the F/A trade-contractor, to

ensure that alarms and tampers not only operate, but that the signal is properly received and responded to by the fire alarm system. See Section 3.17 A 3. for a complete list of devices to be tested.

2. Copy of NFPA 25.

3. Description of systems

   a. List each piece of equipment with manufacturer, model number, and serial number. Model numbers shall be "complete" including any prefixes or suffixes denoting options and accessories.

4. Descriptions of start-up, operating control sequences,, and shut-down

5. Color coded, 8x11 sprinkler-zoning and auxiliary drain maps (see 3.16 for details).

6. Valve charts

7. Spare sprinkler list

8. Schedule of adjustment, care, and routine maintenance for each item of equipment. All instructions shall be legible and easily read, with large sheets of Drawings (if any) folded in

9. Lubrication summary chart for all equipment requiring lubrication. If no equipment requires lubrication, provide a letter so stating.

10. List of spare sprinklers left in the FP service room, and recommended to be kept up to date.

11. Copy of the warranty letter.

12. Copies of any service contracts

1.17 INSTRUCTIONS TO OWNER'S PERSONNEL

A. The Fire Protection Trade-Contractor shall provide qualified, factory-trained, manufacturer's rep(s) to provide a minimum of 8 hours training to the owner's maintenance personnel in the proper operation, care, and maintenance of all equipment. All such training shall be at the job site.

B. FP trade-contractor shall bring to the training:

1. A sign in sheet - have all attendees print their name on the sign-in sheet

2. A written list of all topics specified to be covered, with an "initial line" next to each, and an Owner's signature line at the bottom.

3. FP trade-contractor shall have the "lead" attendee initial each topic as it's covered, and sign at the bottom when all topics are completed.

4. Submit sign-in sheet and signed-off topics list with the training video.

C. Training must meet all MSBA training requirements, specified under section 017900. It also must address all phases of NFPA 25 required maintenance, including but not limited to the following:

D. Explain the code requirement that sprinklers be a minimum of 18" above the top of all storage. Ask staff to keep an eye out for storage that is too close to sprinklers, and to ask the responsible persons to lower their storage height and keep it down..

E. Explain that FP maintenance per NFPA 25 is now a state law requirement. Maintenance must both be completed, and *documented.*

F. On a full-size set of As-built drawings, Mark with red clouds, and yellow high-lighter, the location of all control valves, riser valves, pressure gages, flow switches, tamper switches, drains, and spare sprinkler storage to be checked as part of the maintenance program. Color-code each building flow zone with a unique color.

G. Take personnel to the location of the spare sprinkler cabinet. Provide a list of the sprinkler types stored in the cabinets, and the quantity of each type, and show personnel what each type looks like and where it is used.

H. Take personnel to all pressure gage locations. Show them how to open the gage valve, and describe what the normal pressure ranges should be. Tell them what action to take if pressures are "low".

I. Take personnel to all risers and flow switch locations and show them what a riser valve and flow switch look like, and how they operates. Tell and show them what flow zone each riser and flow switch alarms.

J. Take personnel to all control valve locations. Explain what a tamper switch is, and to call the Fire Dept. if they want to test the valves. Show them how to fully close and then fully open each valve.

K. Take personnel to the back-flow preventor. Explain who to call to arrange for State-required inspections.

L. Describe to personnel what to look for in their annual inspection of sprinklers and piping for "loading", damage, corrosion, and extra weight.

M. Take personnel to all areas with sprinklers that could be subject to freezing if automatic dampers fail open, or manual-dampers are left open. Show them how to tell if dampers are closed and who to contact if they are open..

N. Take personnel to the hydraulic name-plate locations. Explain the purpose and importance of the name-plates.

O. Take personnel to the main drain location, and explain how to arrange for the required, annual, full-flow test with the local fire dept.

P. Take personnel to the FDC – explain its purpose and how to look for damage.

Q. Supply qualified personnel to operate equipment for a sufficient length of time to

ensure that the Owner's representatives are properly qualified to take over operation and maintenance procedures. The Owner shall determine which (if any) systems require additional instructions beyond the minimum number of hours in paragraph A. Duration of instructions shall take equipment through complete cycle of operation.

R. Make a video recording of the Owner training, and provide 2 copies to Owner on CD or DVD (owner's preference)

1.18 SEISMIC RESTRAINTS

A. Seismic bracing and restraints are required by these contract documents.

B. Install bracing and restraints for all Fire Protection equipment, accessories, piping, and components in accordance with NFPA 13, with the following exceptions:

C. All FP seismic bracing shall be attached to structural steel – no deck attachments permitted.

D. All FP piping under stairs and stair landings shall be attached to stair structure, and run close enough to the structure attachment to eliminate the need for EOL restraints.

E. Cable-bracing shall not be used in exposed areas such as mechanical spaces.

F. Piping shall be run close enough to the deck (intermediate floors) or roof structure (top floor) to brace or restrain using pipe or cable 10' or less in length.

1.19 FLOW TEST, SHOP DRAWINGS AND CALCULATIONS

A. This trade contractor shall provide a new flow test in conjunction with the local water department and witnessed by the engineer of record. The new flow test shall occur as soon as possible after being contracted.

B. The flow test shall be performed during a period of "ordinary demand" – occurring between 9-5 pm on a week-day, If at all possible the test shall occur during the months of May to Sept.

C. The flow test shall be performed in accordance with NFPA 291, as follows:

1. Flow and gage hydrant locations shall be as shown on the bid-set documents. In general, the gage hydrant will be the closest hydrant to the FP service entrance, and will be between the flow hydrant and the largest main serving the area.

2. Use only gages calibrated within the last 12 months. Gages used shall bear the sticker of the calibrating company / person, indicating the date of last calibration. If new gages are provided, the static pressure at the gage hydrant shall be initially read with all gages (each one in turn), to check their consistency.

a. Gage hydrant gage shall be a 0-200 psi gage, with 1 psi increments.

b. Flow hydrant pitot gages shall be 0-50 or 0-60 psi, with 1 psi increments.

3. Before reading any gages, flush debris out of the hydrant to prevent damage or inaccurate gage readings. Also bleed air out before reading.

4. Flow a sufficient number of 2-1/2" outlets / hydrants, to flow the fire-flow demand, *or* provide a residual pressure 25% lower than the static pressure. All flowed outlets shall be read simultaneously with the residual gage reading. The flow of all opened hydrants / outlets shall be added together to obtain the total gpm flowed. Avoid pitot readings less than 10 psi or more than 30 psi, by flowing fewer or more outlets.

5. Provide a detailed report – including: a cover sheet with the contractors contact info, time and date of test, a to-scale sketch showing the location and elevation of all flow and pressure hydrants, actual pitot readings, as well as translated flow and pressure results

D. Shop Drawings and Calculations

1. Calculations and shop drawings shall be submitted by construction "phase" – see timing schedule item 7 below.

2. Shop drawings and calculations shall be submitted at the same time, but each shall be in it's own separate submittal package. Shop drawings and calculations shall be submitted to the engineer of record un-stamped, and un-locked, to allow the reviewers to put comments directly on them. Final drawings and calculations approved by the engineer of record shall be submitted *stamped* to:

   a. Engineer of Record
   b. Building Department.
   c. Fire Department.
   d. User Agency's Insurance Underwriter.

3. Shop drawings and calculations shall meet all the requirements of NFPA 13 and 780 CMR 9th Edition

4. Electronic bid-set files are available to facilitate the preparation of the sprinkler shop drawings. These files are solely for the use of the Fire Protection Contractor and may not be a full representation of the Scope of Work. These files are available from Lamoureux Pagano Architects Associates, Inc. (LPA), upon signing of LPA's consent form.

5. Shop drawings shall include all bid-set changes conveyed to the contractor by:

   a. Conformed-with-addenda drawing set
   b. RFI responses
   c. ASIs.

6. Shop drawings may be prepared by a NICET-certified Level III or IV automatic sprinkler system engineering technician but shall be stamped by a professional engineer registered in the jurisdiction of the Project AFTER they are approved by the Engineer of Record.

7. Calculations and shop drawings timing with each "phase".

a. The drawings and calculations for each phase shall be submitted at the same time, a minimum of 8 weeks before the FP trade contractor is scheduled start installation of that phase - whether coordination for that phase is complete or not.

b. Drawings submitted for each phase shall show at minimum: a legend showing and defining all sprinkler types, and all drawing symbols used on the drawing; all calculation design areas in that phase; all sprinklers and piping within each design area; all piping and fittings running from each design area to the gage hydrant; all pipe sizes; and all sprinkler and hydraulic reference numbers.

c. Drawings and calculations shall be completed and updated with any additional coordination changes at the same time they are updated per the reviewer's comments.

d. If coordination is not yet complete when updating the shop drawings per the reviewer's comments, remaining updates shall be included in the as-builts. The FP trade contractor's best estimate of the number of additional coordination (45 degree) offsets that may still be required shall be included in the re-submitted calculations for that phase. Calculations shall also be updated with actual coordination offsets for the record set.

8. Calculation standards:

a. Calculations shall include a table of contents listing the calculation numbers, the calculation areas, and the page number each calculation starts on.

b. For their sprinkler design flow test available pressure and available flow, the contractor shall use the lower of the 2 flow tests available (design team's test and contractor test). Available pressure and flow typically vary seasonally, and the worst case shall be used for design.

c. Where low-loss pipe fittings have been submitted, the fitting losses used in the calculations shall match the manufacturer's listed losses (adjusted for schedule 10).

d. Contractor's sprinkler pipe sizing must include the following, minimum safety margins:

i. 10 psi over and above the worst-case flow test results.
ii. Pipe sizing shall not be reduced below bid-set sizing for the underground parking area dry systems. NFPA 13 2022 is proposed to increase parking garage hazard level to OH-2 because of the greater amounts of plastics in cars.

e. FDC design available flow and pressure shall be 1,000 gpm available at 150 psi (final pressure after city water is boosted by WFD pumper.)

f. All Pipe shall be sized to not exceed a maximum water velocity of 25 feet per second.

g. Hydraulic calculations may be prepared by a NICET-certified Level III or IV automatic sprinkler system engineering technician but shall be stamped by a professional engineer registered in the jurisdiction of the Project AFTER they are approved by the Engineer of Record.

PART 2 PRODUCTS

2.1 GENERAL

A New products: Except as specified otherwise, material and equipment shall be new. Provide all components required or recommended by OSHA.

B Standard Products: Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products for at least 3 years.

C Multiple Units: When two or more units of materials or equipment of the same type or class are required, these units shall be products of one manufacturer.

D Nameplates: Each item of equipment shall have a name-plate bearing the manufacturer's name, address, model number, and serial number, plus compliance labels, and any other information needed for identification securely affixed in conspicuous places; the nameplate of the distributing agent alone is not acceptable. The nameplates shall be kept clean and readable at all times.

E Asbestos products or equipment or materials containing asbestos shall not be used.

2.2 MATERIALS AND EQUIPMENT

A Do not order or deliver any materials until all submittals, required in the listed Specification Sections included as part of this Filed Trade-contract, have been received and approved by the Engineer.

B The Fire Protection Trade--Contractor shall be responsible for the ordering, handling, and security all materials and equipment required for a complete job. Each Trade-Contractor shall be solely responsible for ensuring that sufficient materials are on site so that the work can proceed in a smooth, continuous fashion.

C Each Trade-contractor shall be responsible for his work until its completion and final acceptance, and he shall replace any work or materials that have been damaged, lost, or stolen without additional cost to the Owner

D Each Trade-Contractor shall verify all existing site conditions and material needs before starting work on any task and before ordering delivery of any materials and/or equipment. Each Trade-Contractor shall coordinate the time of delivery of all equipment and materials and have a designated representative present to sign for the receipt of all equipment and materials.

2.3 DELIVERY, STORAGE, AND HANDLING

A Upon delivery, each Trade-Contractor shall move their materials to their proper

storage site. It shall be the Trade-Contractor's responsibility to arrange with the G.C. for storage areas.

B Carefully store materials and equipment which are not immediately installed after delivery to site. It shall be each trade's responsibility to store their materials in an orderly and clean manner. If stored on-site in open or unprotected areas, all equipment and material shall be kept off the ground by means of pallets or racks, and covered with tarpaulins.

C Deliver un-cut pipes and tubes with factory-applied end-caps. Maintain end-caps through shipping, storage, and handling to prevent pipe-end damage and prevent entrance of dirt, debris, and moisture.

1 Piping that has been cut, threaded, or grooved off site shall be delivered shrink wrapped to prevent entrance of dirt, debris, and moisture.

D Protect all materials and equipment from moisture and dirt and extreme temperatures. Store in the manufacturers carton or crate until installation.

2.4 LABELING AND IDENTIFYING

A All labeling systems shall meet ANSI 13.1 requirements.

B Provide labels on all new equipment and new distribution systems provided under this contract. Coordinate equipment numbers with the User Agency's maintenance personnel. Stencils shall be at least 2 inches high and of a color to provide a contrast with the equipment finish.

C Above-ceiling valves and drains: Where-ever control valves or low-point drains are installed above a ceiling, provide a valve (or drain) tag and valve (or drain) label installed on the "best" ceiling tile to move to access that valve or drain. Note exact location (within 1 ceiling tile) of above-ceiling valves and drains on the record drawing set.

D Piping Systems:

1 All FP piping between the backflow preventor and the ZCVs is considered "standpipe". All Piping from the ZCVs out is considered "sprinkler".

2 Piping systems may be identified with stenciling or with approved snap-on covers. Markers shall be equal to Seton Setmark.

3 Install all pipe labels during rough-in.

4 Pipe marking for outside diameters of 6 inches or greater may be springs or metal bands secured to the corners at each end of a semi-rigid plastic marker to hold each end of the marker firmly against the pipe.

5 Labeling shall be applied on the apparatus in full view i.e. visible from both sides as well as from below. Labeling shall be a color that is in sharp contrast with the background. The apparatus shall be thoroughly cleaned (and painted, if necessary) before labeling is applied. Letters shall not be less than 1 ½" in height. Arrows shall not be less than 9" long.

6 Provide labels and arrows showing normal direction of flow:

a. Near each valve and control device.

b. Near each branch, excluding short take-offs for fixtures and terminal units.

c. Near locations where pipes pass through walls, floors, ceilings, or enter inaccessible enclosures.

d. Near major equipment items and other points of origination and termination.

e. Spaced at a maximum of 20-foot intervals along each run.

7 Marker letter sizes shall be as follows:

	Pipe Outside Diameter	Letter Size	Length
b.	1-1/4 inch and smaller	1/2 inch	8 inche
c.	1-1/2 inch to 2 inch	3/4 inch	8 inches
d.	2-1/2 inches to 6 inches	1-1/4 inch	12 inches

8 Marker Text and colors shall be as follows:

	Service	Identification	Color
b.	Wet System Piping	Fire Protection - Wet	Red
c.	Dry System Piping	Fire Protection – Dry	Red
d.	Standpipe	Standpipe	Red
e.	Drain Piping	FP Drain	Red

E Valves: All new valves shall have near circular brass or engraved plastic valve tags of at least 1-¼” in diameter, attached with brass hooks (beaded chain is not acceptable) to each valve stem.

1 Valve tags shall have ¼” high lettering for the service (i.e. “FP”) with 1/2” high consecutively numbered valve numbers.

2 Plastic valve tags shall be color coded as specified for piping identification.

3 Service designations shall be as follows:

	Fire Protection System:	Designation:
b.	Wet Systems	FP
c.	Dry Systems	FP
d.	FDC / Standpipe	StdP
e.	Drain	D

4 Valve numbers:.

a. The numbers for each service shall be consecutive, and shall be shown on the record drawings.

F Adjusting: Relocate identifying devices which become visually blocked by work of this Division or other Divisions.

2.5 MANUFACTURERS

A Available Manufacturers: Subject to compliance with requirements, manufacturers offering fire protection system products which may be incorporated in the work include, but are not limited to, the following:

1 Control Valves and Tamper Switches:

a. Tyco Fire Products
b. Jenkins
c. Kennedy Valve, Division of ITT Grinnell Valve Co., Inc.
d. Stockham

2 Swing Check Valves:

a. Tyco Fire Products
b. Jenkins
c. Kennedy Valve, Division of ITT Grinnell Valve Co., Inc.
d. Star Sprinkler Corp.
e. Stockham
f.

3 Grooved Mechanical Fittings:

a. Stockham
b. Victaulic
c. Grinnell

4 Water Flow Indicators:

a. Potter
b. Reliable Automatic Sprinkler Co., Inc.
c. Tyco Fire Products
d. Victaulic Company of America
e. Viking Corp.

5 Alarm Check Valve, Riser Check Valve,

a. Reliable Automatic Sprinkler Co., Inc.
b. Tyco Fire Products
c. Viking Corp.

6 Fire Department Connection Valve and Interior Hose Connections:

a. Guardian Fire Equipment, Inc.
b. Croker Valve
c. Viking Corp.

7 Sprinkler Heads

a. Automatic Sprinkler Corp. Of America
b. Firematic Sprinkler Devices, Inc.
c. Globe Fire Equipment Co.
d. Guardian Fire Equipment, Inc.
e. ITT Grinnell
f. Reliable Automatic Sprinkler Co., Inc.
g. Tyco Fire Products
h. Viking Corp

8 Backflow Preventor

a. Watts
b. Ames
c. Zurn

9 Hangers and Sway Brace Components

a. Tolco
b. Afcon
c. Viking
d. Anvil International

10 Clean Agent Fire Suppression Systems

a. Tyco Fire Protection Products (Ansul Sapphire)
b. Kidde
c. Fire Trace International

11 Fire Command Center valve and water-flow detector display panels

a. NOTIFIER; a Honeywell company
b. Edwards Systems Technology
c. Johnson Controls Inc.
d. Potter Signal

2.6 PIPING, FITTINGS AND JOINTS

A General

1 All piping passing thru exterior walls (FDCs and Drains) shall be hot dip galvanized, including the threads.

2 Pipe and fittings shall conform to the latest ANSI, ASTM, NFPA and AWWA Standards including latest amendments.

3 Each length of pipe, each pipe fitting, and/or device used in the piping systems shall have cast, stamped or indelibly marked on it, the maker's name or mark,

weight and quality of the product when such marking is required by the approved standard that applies. Pipe and fittings shall conform to the latest ANSI, ASTM, NFPA and AWWA Standards including latest amendments.

4 Piping and fittings specified as “coated” shall be factory coated.

5 All joints shall be line-size, with an equal or greater pressure rating as the pipe.

B Where ever steel or iron metals are joined to copper, brass or bronze, they shall be separated by a dielectric nipple, or flanges with dielectric gasket. No dielectric unions permitted.

C All equipment and materials used shall be listed for the use required and for a minimum of 175 psi.

D Service Entrance Piping:

1 Black steel Schedule 4O, ASTM A53 with flanged, threaded, or grooved joints.

2 Black steel Schedule 10, ASTM A135 light-wall with roll-grooved fittings – size 2-1/2” and over ONLY.

E Wet System Piping:

1 Steel:

a. 2 inches and smaller: ASTM 135 Schedule 40 black steel with roll-grooved or threaded joints;

b. larger than 2 inches: ASTM 135 Schedule 10 light-wall with roll grooved joints

2 Copper: Type L or K copper with 95-5 soldered or brazed joints in compliance with NFPA 13. Provide dielectric fittings between copper and ferrous piping.

3 Exposed piping inside of hose cabinets shall be galvanized or chrome plated.

F Dry system piping – same as wet system, except hot dip galvanized inside and out.

G Fittings:

1 Flexible Sprinkler Connectors – shall be braided stainless steel, UL listed and FM approved for the design length, bend radius, and number of elbows to be used.

2 Ductile Iron: ASTM A-536.

3 Malleable Iron: ANSI B16.3.

4 Steel: ANSI B16.11.

5 Cast Iron: ANSI B16.4. (Not for use in dry system.)

H Grooved Fittings and Couplings:

1 Grinnell Fig. 7000, Gustin-Bacon No. 105 or Victaulic Firelock or Style 75. Use manufacturers friction loss data in hydraulic calculations, modified per NFPA 13 to schedule 10 piping equivalent lengths, where schedule 10 piping is used.

2 Both Flexible and rigid couplings required, per NFPA 13.

3 Compatibility: Grooved ends, Couplings and fittings shall meet ANSI / UL 213 standard grooved dimensions for fire protection service.

2.7 JOINING MATERIALS

A Welding Materials: Comply, with Section II, Part C, ASME Boiler and Pressure Vessel Code for welding materials appropriate for the wall thickness and chemical analysis of the pipe being welded.

B Brazing Filter Metals: AWS A5.8, Classification Bag1 (Silver).

C Solder Filter Metals: ASTM B 32, 95-5 Tin Antinomy.

D Gasket Materials: Thickness, material, and type suitable for fluid or gas to be handled, and design temperatures and pressures.

2.8 SLEEVES AND PENETRATIONS,

A Sleeve Types

1 Pipe sleeves passing thru or under below grade walls and footings, shall be ductile iron, three sizes larger than the pipe being served. Sleeve shall be a minimum of six feet in length.

2 Pipe sleeves through floors, exterior walls and fire-rated construction shall be galvanized Schedule 40 steel pipe.

a. Piping penetrations through fire rated construction shall comply with a listed fire rated assembly as detailed in the UL Fire Resistance Directory.

3 Pipe sleeves through non-fire-rated partitions shall be 26 g. galvanized steel.

B Water-proofing: Sleeves Through Exterior Foundation Walls and Floor Slabs on Grade: shall have a continuous-welded flange water stop and waterproof caulking assembly by Link-Seal or Sure-Seal.

C Sleeve Sizing:

1 Annular Space Requirements: Sleeves shall be sized to provide a uniform clearance around the pipe / insulation cover:

a. 1" for pipe 3-1/2" and under
b. 1" for pipe 4" and over with listed flexible coupling on both sides of the structure, within 1' of the penetration.
c. 2" for pipe 4" and over without flexible coupling
d. Annular space around penetrations thru fire rated assemblies shall be in compliance with the Listed Assembly.

2.9 FIRE STOPPING

A Materials shall be asbestos-free, complying with UL 1470 and UL Fire Resistance Directory.

B Submit installation instructions with the fire-stopping submittal.

C See Section 07 84 00 for specific product requirements.

2.10 INSERTS AND ESCUTCHEONS

A Provide anchors and inserts as necessary for attachment of equipment supports and hangars.

B Inserts shall be individual or strip type of pressed steel construction with accommodation for removable nuts and threaded rods up to 3/4 inch diameter. Strip type shall permit lateral adjustment. Strip inserts shall have attached rods with hooked ends to allow fastening to reinforcing rods.

C Inserts shall develop strength of bolt when installed in properly cured concrete.

D Concrete anchors used to secure either hangers or sway brace assemblies to the building structure shall be in accordance with ACI 355.2, and installed per manufacturer's instructions.

E Pipe escutcheons 2" and under shall be cast brass chrome plated type. Escutcheons 2-1/2" and over may be cast iron, with a set screw to properly hold escutcheon in place.

2.11 GENERAL DUTY VALVES

A Valve ends specified below as "threaded" or "flanged", may also be groove-end if attaching to grooved piping of the specified wall thickness.

B Gate valves shall be UL listed for at least 175 psi working water pressure (wwp).

1 2 inches and smaller shall be outside screw and yoke, bronze, rising stem, wedge disc type, threaded, conforming to MSS SP-80.

2 2-1/2 inches and larger shall be iron body, bronze trim, outside screw and yoke, flanged, UL/FM listed conforming to MSS SP-70.

C Globe and angle valves may be used as auxiliary valves (drain valves, test valves, trim valves and valves on compressed air piping) for diameters not over 2 in. They shall be bronze, rising stem, with bronze disc, threaded, conforming to MSS SP-

80 Class 150.

D Butterfly valves:

1 3 in. and larger shall be lug style, ductile iron body, ductile iron nickel plated disc, stainless steel stem, gear operated, with a position indicator, U4 listed for 175 psi conforming to MSS SP-67.

2 2-1/2 in. and smaller shall have a 175 psi bronze body with threaded ends, stainless steel disc and stem, visual position indicator, and a built-in tamper proof supervisory switch rated 10 amps, 115 VAC.

E Check valves shall be swing type except as noted. Valves 2 inches and smaller shall be bronze, regrinding type with renewable disc, screwed caps, threaded, class 150 conforming to MSS SP-80. Check valves 2-1/2 inches and greater shall be iron body, bronze trim, bolted cover, flanged, conforming to MSS SP-71, UL listed for 175 psi

2.12 SPECIALTY VALVES

A Riser Check Valve: 175 psig working pressure, designed for horizontal or vertical installations, and have cast iron, flanged inlet and outlet, bronze grooved seat with O-ring seals, single hinge pin and latch design. Provide trim sets for bypass, drain, electric sprinkler alarm switch, pressure gauges, retarding chamber, drip cup assembly piped without valves separate from main drain line, and fill line attachment with strainer.

1 Provide with optional 175 pressure relief valve, UL listed for FP service.

B. Quick opening device: Capable of operating up to 4 dry risers, monitors pressure twice a second, 4 second opening time if 3 monitoring intervals show consistent pressure loss of .1 psi/second, battery backup for 120 V hard-wire power. Tyco VIZOR or approved equal.

C. Dry System Valve: differential type, 175 psig working pressure, and have cast iron, flanged inlet and outlet, bronze seat with O-ring seals, single hinge pin and latch design. Provide trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gauges, priming chamber attachment, fill line attachment, and quick opening device. Tyco DPV-1 or approved equal.

D. Air-pressure maintenance device, dry-pipe system: an automatic device to maintain the correct air pressure in a dry-pipe system or deluge system. System shall have shut-off valves to permit servicing without shutting down the sprinkler system, bypass valve for quick system filling, pressure regulator or switch to maintain system pressure, strainer; pressure ratings 14 to 60 psig adjustable range, and 175 psig maximum inlet pressure. General Air Products AMD1 or approved equal.

E. Dry Drains: Galvanized, auxiliary drain with powder-coated and labelled, red anti-trip plate (ATP) that prevents to opening of either ball valve unless the other valve is closed. 2”x12” condensate nipple, 2, 1” brass, quarter-turn ball valves with chrome plated balls, 1” galvanized square head plug. AFG 5200A or approved equal.

~~B~~F Hose Valves: 175 psig working pressure, straight or angle pattern suitable for the application, bronze body gate valve with 2-1/2" FNPT inlet and combination 2-1/2" / 1-1/2" FMST outlet, and cap and chain. Install all hose valves centered in hose cabinet, with valve outlet angled down approximately 30 degrees.

1 All Hose valve cabinets are provided by the G.C. This sub-contractor shall coordinate the installation of the hose valve cabinet to provide maximum working space for attaching hoses and operating the valve.

~~C~~G Roof Hydrants: Free-standing, cast-brass, back-angle body, with male hose threads and caps and chains. With rough chrome cover sleeve and roof-water-proofing-boot. Provide hand-wheel and sight window to confirm valve operation. Cast-brass plate lettered, "HYDRANT". 6" inlet, and 2, 2-1/2" outlets, mounted a minimum of 36", and a maximum of. 60" above finished roof. Provide normally closed, manual drain valve and ball drip, both piped to an approved drain.

~~D~~H Roof Hydrant Valve Control: Free-standing, with hand-wheel mounted 46" +/- above finished roof, and sight-window to confirm extension-stem-turning.. With Brass cap, brass sleeve, brass base plate, and roof-water-proofing-boot. Provide extension stem of sufficient length to run from hand-wheel to non-rising-stem gate valve below roof line. Provide plug-type (Potter PTS-C or approved equal) tamper switch at PIV handle.

2.13 GAUGES

~~A~~F General

1 Pressure Gauges shall be as manufactured by U.S. Gauge, Ashcraft, Trerice or equal, and listed for Fire Protection service.

2 The accuracy of all gauges shall be 3-2-3% of full-scale (i.e. 3% accuracy in the bottom quarter of the range, 2% accuracy in the middle half of the range, and 3% accuracy in the top quarter of the range.)

3 All gauges shall be selected so the normal operating pressure is in the middle 1/2 of full-scale (i.e. 2% accuracy range)

~~B~~G Pressure Gauges

1 Gauges shall be installed with a suitable gauge cocks to permit servicing.

2 All gauges shall be minimum 3-1/2-inch diameter, dial type, ABS case, phosphor bronze bourdon tube, 1/4 inch forged brass N.P.T. male socket connection with wrench flats, white lithographed steel dial with black numbers and graduation. Dial graduations shall read in "PSIG".

2.14 BACKFLOW PREVENTION DEVICES

F Double Check-type backflow preventers shall have300 series stainless steel valve body and sleeve, grooved connections, replaceable check disk rubber, stainless steel internal parts, bronze-bodied ball valve test cocks, non-rising stem gate valves or UL/FM butterfly valves with integral tamper switches, and inlet and outlet pressure gauges. Comply with requirements of ASSE Standard 1013. Size as

indicated on the Drawings.

1 Furnish one (1) spare parts kit for each size of device to be installed.

2 Furnish one (1) test kit for use with the reduced pressure devices. The test kit shall be contained in its own carrying case.

2.15 AUTOMATIC SPRINKLERS

~~A~~F Sprinkler Heads:

1 Flat-plate, concealed type in all ceilings This includes dry concealed pendants in walk-in coolers and freezers.

1. Fusible link type uprights where exposed.

~~1~~2 Other styles as indicated by the drawing legend.

~~2~~3 Except where otherwise indicated, provide standard coverage sprinklers with nominal 1/2 inch NPT connections

~~3~~4 Where sprinklers with a higher K-factor than 5.6 are indicated, they shall have a minimum ¾ inch NPT connection – to prevent accidental replacement with a K5.6 coverage sprinkler.

~~2~~5 Sprinklers shall be “intermediate” temperature rating through-out, except where code required to be high temperature.

~~3~~6 Provide sprinkler guards on all exposed upright sprinklers in the gym, storage rooms, mechanical rooms, under stairs and under open-joist mezzanines.

~~4~~7 Dry sprinkler lengths shall be selected per section 3.11 G. Any length of dry sprinkler within wall insulation is not considered to be within “heated space”.

~~B~~G Sprinkler Heads Finishes: Provide heads with the following finishes:

1 Specialty ceilings include all non-continuous and non-white ceilings. Architect to choose sprinkler finish colors from the full range of custom colors offered.

a. Sprinkler and concealed pendant cover plate finishes must coordinate with all ceilings, including black, dark red, and metallic ceilings.

b. Water shields (if required) shall be painted (factory or shop) to match the sprinklers with which they are installed.

c. Upon request, Architect will provide color samples to be matched.

2 Standard Ceilings include all continuous, white ACT or sheetrock ceilings.

a. Concealed pendants – white covers,
b. Pendent, and Sidewall Styles: chrome plated in finished spaces, exposed to view;

c. rough bronze finish for heads in unfinished spaces or not exposed to view.

3 No ceilings: Upright style – rough bronze finish.

2.16 FIRE DEPARTMENT HOSES AND RACKS

~~A~~F None required – per Worcester Fire Dept.

2.17 FIRE DEPARTMENT CONNECTIONS

~~A~~F Wall Type Siamese Connections: Polished cast brass or chrome, flush wall type, with cast brass or chrome wall escutcheon and 2-1/2" inlets. Inlet shall have a clapper valve, and plug and chain. Unit shall have a finish to match connections, and be labeled with raised letters: AUTO SPKLR-STDPIPE FDC

1 For standpipe systems (fully sprinkled building), each FDC shall have 4, 2-1/2" inlets, and a 6 inch female outlet, having NH standard threads. Pattern of inlets shall be vertical stacked, horizontal side-by-side, or square pattern at the owner's discretion.

~~2.13~~2.18 ALARM DEVICES

~~B~~F General: Types and sizes shall mate and match piping and equipment connections.

~~F~~G Wet System Water Flow Indicators: Vane type water-flow detector, rated to 250 psig; designed for horizontal or vertical installation; have 2-SPDT circuit switches to provide isolated alarm and auxiliary contacts, 7 ampere 125 volts AC and 0.25 ampere 24 volts DC; complete with factory-set, field-adjustable retard element to prevent false signals.

~~C~~H Supervisory Switches (for valves): SPST, normally closed contacts, designed to signal valve in other than full open position.

~~D~~I Alarm Pressure Switch (dry system alarm): Die-cast NEMA 4/IP66 enclosure and red-powder-coated cover with rain-lip and set screw. UL listed / FM approved, 300 psi rated, 4-8 psi factory adjustment with 2 psi differential. SPDT (form C) contact with ground screw, rated 10 A / 125VAC or 2 A / 30VDC. Potter PS10-1 or approved equal.

~~E~~J Supervisory Pressure Switch (dry system High or low-air-pressure). Die-cast NEMA 4/IP66 enclosure and red, high-impact-composite cover with rain-lip and set screw. UL listed / FM approved, 300 psi rated, 10-60 psi factory range – factory set to 40 psi normal pressure. SPDT (form C) contact with ground screw, rated 10 A / 125VAC or 2 A / 30VDC. Activates on 10 psi pressure drop, or 10 psi pressure rise. Potter PS40 or approved equal.

~~F~~K Electric Bell: UL listed and FM approved, 24 VAC, 90 dBA volume, suitable for outdoor use, mounts to standard 4x4 box, red-powder coating. Potter PBA248 or approved equal.

~~2.13~~**2.19** PIPE AND HANGER SUPPORTS

~~A~~F Provide pipe stands, supports, hangers, and clamps conforming to NFPA 13 and listed by UL and approved by FM. All components of the hanger support system shall comply with the standards set forth in MSS-SP58 and MSS-SP69 (Manufacturers Standardization Society) latest publication.

~~B~~G Provide protection of piping against earthquake damage including sway braces, end-of-line restraints, and flexible connections in accordance with NFPA 13. Provide seismic separation assemblies capable of 1" movement in all directions on all piping crossing any building seismic joint – Metraflex or approved equal. All assemblies shall be UL listed and FM approved for seismic restraint.

~~C~~H Acoustical roof decks (may be installed in the gym, Auditorium, and cafeteria, and / or music rooms) have a perforated metal plate underneath the baffled deck structure, which prevents C-clamp retaining straps from being installed. The metal plate also prevents the use of some seismic attachments attached to the top flange of beams and bar joists. In order to properly attach to roof structure in these areas the following are specified:

1 Hanger attachments in gym shall both "fit" and be listed for use as a hanger without a retaining strap on the bar joist vertical top flange – Anvil Fig. AF087 or approved equal.

2 Seismic attachments in gym shall both "fit" and be listed for use on the bar joist vertical top flange - .Anvil Fig. 778 or approved equal.

~~D~~I Hanger Types

1 Provide galvanized hangers, attachments, and hardware for steel and plastic piping.

a. Hangers for uninsulated steel or cast iron piping shall be Carpenter & Patterson Figure 1A galvanized-steel adjustable band type or Carpenter & Patterson Figure 100 galvanized-steel clevis type

b. Extension type split ring hangers with wall plates shall be equal to Carpenter & Patterson Figures 81, 81-CT, 90-CT and 85, 85-CT plates for iron, steel and copper.

c. Perforated strap hangers are not acceptable.

~~E~~J Hanger rods shall be sized in accordance with NFPA 13, and the recommended load capacities of ASTM Specifications Designation A-107, latest amendment.

~~2.19~~2.20 ACCESS PANELS

~~A~~F Furnish access doors and frames for walls and ceilings to applicable trades for installation. Minimum size 16x16 for ease of access and maintenance.

1 See section 08 31 00 for product specifications.

~~2.14~~2.21 DRY SYSTEM ACCESSORIES

~~B~~F Air compressor: tank-mounted, oil-less compressor trimmed with valved pressure gage, pressure switch, isolation valve, air maintenance device, drain, relief valve, and check valve. Gast Manuf. Inc 8LDF-46T-M850X or approved equal. Minimum capacity 8.84 cfm / 2 HP.

~~2.15~~2.22 VALVE AND WATER FLOW DETECTOR DISPLAY PANEL

A As required by 780 CMR section 911 for high rise buildings.

B Must provide continuous display of the valve status (open or closed) and water-flow detector status (normal or tripped) for all control valves and water flow detectors in the FP system.

~~2.20~~2.23 CLEAN AGENT FIRE SUPPRESSION SYSTEM

F. This specification is based on an Ansul Sapphire Clean Agent system (manufactured by Tyco) – available thru Johnson Controls Fire Protection LP, an Ansul distributor certified for the design, installation, and maintenance of this system.. .

G. Clean agent system shall be a Novec 1230 total flooding fire suppression system designed to provide a uniform concentration of agent for the protected area:

1. The amount of Novec 1230 agent to be provided shall be the amount required to obtain a uniform (minimum) concentration of 4.5 ppm for the time period specified in the manufacturer's design and installation manual. Take into consideration such factors as non-closable openings (if any), "rundown" time of fans, time required for dampers to close (and requirements for any additional dampers), and any other feature of the facility that could affect concentration. The design concentration shall be by volume at 70 ℉ (21 ℃).

H. System provided shall include all smoke detectors, manual pull stations, manual abort station, 2 (main and reserve) agent cylinders with mounting brackets, alarm devices, releasing devices, discharge nozzles, piping, wiring, control panel, and output modules for alarm, trouble, and supervisory to provide a complete system operating per the sequence of operations outlined below. System shall also include all design, installation, and testing documents outlined under section 1.9 Submittals.

I. Smoke Detection: shall be Aspiration Smoke Detectors (ASD) for very early warning smoke detection. Smoke detectors and ASD sample points shall be installed at no more than 250 ft^2 (23.2 m^2) of coverage per detector. In all cases, the compatibility listings of the detectors for use with the control unit should be observed. The system shall require two detectors in alarm prior to automatic agent release.

J. Sequence of Operations: Single Smoke Detector Activated shall:

1. Cause a first-stage alarm.
2. Energize a lamp on the activated detector and identify detector on the display of the control panel (and remote annunciator, if included).

Note**: The shutdown of electrical equipment will be optional at this stage based on requirements of the local AHJ or applicable standards.**

K. Sequence of Operations - second smoke detector Activated shall:

1. Transmit an alarm signal to remote fire alarm monitoring panel.
2. Cause a second-stage (pre-discharge) Audio/Visual alarm to operate.
3. Operate auxiliary contacts for air conditioning shutdowns and automatic dampers.
4. Initiate a programmable time delay for agent release.

L. Sequence of Operations - Upon completion of the time delay the system shall:

1. Cause a discharge alarm to be activated.
2. Operate auxiliary contacts for emergency power off of all electrical equipment (excluding lighting and emergency circuits for life safety).
3. Activate visual alarms (strobe) at protected area entrance.
4. Energize control solenoid for cylinders releasing gaseous agent into the protected area.

M. Sequence of Operations – Manual activation: Double action manual releasing stations shall be provided at each exit of the protected area and shall, when activated, immediately release the Novec 1230 agent and cause all audible/visual alarms to activate. In addition, activation of the manual releasing stations shall cause immediate shutdown of air and power circuits.

N. Sequence of Operations – Manual abort: Abort stations shall be provided at each exit of the protected area and shall, when operated, interrupt the discharge of Novec 1230 agent and emergency power-off functions. The abort stations shall be momentary devices (dead-man) requiring constant pressure to maintain contact closure.

1. **Note**: Manual Releasing Station activation shall override any abort station. Abort station operation shall be per IRI and FM guidelines.

O. System shall be sized for the 565 sqft computer Server Room only. System shall include all design, installation, materials, equipment, agent, piping, wiring, control panel and devices, installation, and testing to ensure the above sequence of operations and the required concentration of agent are achieved.

P. Include 2 (main and reserve) piped in, full containers of clean agent.

PART 3 EXECUTION

3.1 SEQUENCING AND SCHEDULING

A. All Fire Protection installations shall be coordinated and timed so as to minimize any additional work required from other trades. Examples include but are not limited to:

1. Concealed sprinkler caps shall not be installed until the ceiling tile for that sprinkler(s) has been installed. The ceiling trade contractor shall not be required to remove and re-install sprinkler caps.

2. Restraints that must pass thru a sheetrocked wall shall not be installed until the sheetrock is hung. The drywall contractor shall not be required to slit their drywall to fit around a restraint cable or hanger.

3. Pipe labels shall be installed prior to the ceiling being enclosed. The designer shall be able to inspect all pipe labelling without the use of a ladder.

B. Pre-Bid Conference: Bidders are strongly encouraged to attend the Pre-Bid conference; refer to INVITATION TO BID for time and date.

C. Phasing: Refer to Section 01 10 00 - SUMMARY, and Drawings for phasing and milestone completion requirements which affect the General Contractor's Work and the Work of this Trade-contractor.

D. Extra payment will be allowed ONLY for additional work caused as-built conditions substantially different than shown on the drawings. No extra payment will be allowed for additional work caused by unfamiliarity with the contract documents or site conditions that are visible or readily construed by experienced observer.

1. Report conditions that might affect work adversely in writing to the Designer.

2. Do not proceed with work until defects have been corrected and conditions are satisfactory. Commencement of work shall be construed as complete acceptance of existing conditions and preparatory work.

E. The Fire Protection Trade-contractor shall layout all work and be responsible for the accuracy of same. Conditions at the project site shall be the determining factor for all measurements, runs, bends, and offsets.

F. Each Trade-contractor shall furnish all sleeves, frames, supports, inserts, and other accessories required for their work so that the General Contractor may build them into place.

1. Each Trade-contractor shall coordinate the installation of supporting devices, chases, openings, sleeves and inserts he requires.

2. The size and location for openings, sleeves, and inserts required by each Trade-contractor shall be checked by that Trade-contractor.

3. In case of failure to provide sufficient information in proper time, resulting in openings, sleeves or inserts that were not installed or were incorrectly located, provide cutting and patching or have same done, at own expense and to full satisfaction of Designer.

G. Provide information requested by others as to sizes, number and locations of concrete housekeeping pads necessary for floor-mounted equipment provided under this Section.

H. Coordinate connection of all electrical wiring prior to testing and final inspections..

I. Coordinate installation of identifying devices after completion of covering and painting where devices are applied to surfaces.

3.2 ROUGH-IN

A. Avoid interference with structure and with the work of other trades.

B. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

C. Each Trade-contractor shall make all measurements, both horizontal and vertical, off reference points established by the General Contractor and be responsible for correct laying out of work.

D. In the event of discrepancies between actual measurements and those indicated, notify Designer in writing and do not proceed with work until written instructions have been issued by Designer.

E. Install all work so that parts requiring periodic inspection, maintenance, and repair are readily accessible. Install concealed devices in locations freely and fully accessible through access doors.

1. Furnish access doors for all concealed items, of sufficient size for proper maintenance. See section 2.20 for product requirements.

2. All access doors shall be installed by the G.C. or other Trade-contractors as specified in 1.03.E.

3.3 CUTTING AND PATCHING

A. Section 01 73 00 defines what coring, cutting and patching shall be done by the General Contractor, and what shall be done by Trade-contractors in the MEP trades.

B. All work and materials shall be installed in such a manner and at such time to keep cutting and patching to a minimum.

C. Each Trade-contractor shall do all drilling required for the installation of their hangers.

D. Coring

1. If coring thru concrete slab, no sleeve is required.

2. If providing a sleeve, do NOT cut through concrete floor slab until after concrete is poured and cured 28 days.

3. Preferred sleeve option is thru the use of Hilti "Platform for Metal Deck Firestop Sleeve" model CFS-CID MD PLT, sized to fit piping.

4. refer to Section 01 73 00 for other coring-related requirements.

E. All pipe cutting and threading shall be done in a location approved by the Engineer.

1. No pipe cutting or threading shall be done on completed, exposed concrete floor slab, unless approved in writing by the General Contractor.

2. If necessary, the Trade-contractor shall cover the entire working area with canvas and plastic tarps.

F. Perform all cutting, fitting, and patching required to:

1. Provide for the installation or inspection of ill-timed Work.

2. Remove and replace defective work or work not conforming to requirements of the Contract Documents.

3. Remove samples of installed Work as specified for testing.

G. Protect the structure, furnishings, finishes, and adjacent materials not scheduled to be removed.

H. Patch existing finished surfaces and building components using new materials that match existing materials and Installers experienced with the materials and methods required.

I. Reference Section 01 73 29 for additional requirements.

3.4 FIRE STOPPING and SOUND SEALING

A. Fire-stop all holes through fire-resistive assemblies used by this Trade-contractor work under this contract.

B. Refer to section 07 84 00 FIRE-STOPPING for installation methods.

C. Sound-sealing: - Seal all openings used by this Trade-contractor into or out of offices, classrooms, bathrooms, mechanical rooms, the library, gym, auditorium, and the cafeteria to minimize sound transmission. Sealant shall be non-combustible.

D. Use of existing openings:

1. “No wall”: If a wall ends at the ceiling, no sleeve, fire-stop, or sound-seal is required where the fire protection piping passes above the wall

2. Existing openings in walls larger than 4 square feet shall be considered “no wall”.

3. If this Trade-contractor chooses to pass their piping thru an opening provided by others, this Trade-contractor shall fire-stop (if required) or sound-seal (if required) the entire hole – regardless of size.

3.5 MECHANICAL INSTALLATIONS – GENERAL REQUIREMENTS

A. General

1. Refer to Division I for additional quality assurance, testing & inspection requirements.

2. Where an installation of any item will be visible, and locations are not shown on the FP or architectural plans or elevations, submit an RFI (request for information) to the Engineer / Architect for direction as to exact location.

3. Install all equipment according to manufacturer’s installation instructions.

4. Provide supplementary or miscellaneous items, accessories, devices and

materials obviously necessary for a sound, secure and complete installation.

5. Install systems, materials, and equipment to provide the maximum headroom possible, and clearing doors and passageways in accordance with code requirements, unless specifically shown at a lower height.

6. Install systems, materials, and equipment neatly, level and plumb, (unless pitch to drain is required), and parallel and perpendicular to other building systems and components.

7. Suspended Equipment and distribution systems shall be installed concealed except in mechanical rooms and areas where no ceiling exists.

8. Installations shall operate safely and without leakage, undue wear, noise, vibration, corrosion or water hammer.

9. All automatic control devices shall be adjusted for proper operation.

B. Installation Only Items

1. Obtain final roughing dimensions or other information as needed for complete installation of items furnished under other Sections or by User Agency.

2. Where the Fire Protection Trade-contractor is required to install items which it does not purchase, it shall:

   a. Coordinate their delivery, and be responsible for their unloading from delivery vehicles and for their safe handling and field storage up to the time of installation.

   b. Carefully examine such items upon delivery. Claims that any of these items have been received in such condition that their installation shall require procedures beyond the reasonable scope of work of the Fire Protection Trade-contractor will be considered only if presented in writing within one week of their date of delivery. Unless such claims have been submitted this contractor shall be fully responsible for the complete reconditioning or replacement of the damaged items.

   c. This trade shall be responsible for: any necessary field assembly, internal connections, mounting in place, and their connection to building systems including the purchase and installation of all terminating fittings necessary to adapt and connect them to the building systems.

C. Equipment

1. Verify site conditions and dimensions of equipment to ensure equipment can be properly installed and maintained without disassembly. Provide all manufacturer's recommended service clearances.

2. Install equipment to properly distribute equipment loads on building structural members or equipment supports provided under other Sections.

3. Provide cuts, weights, and other pertinent data required for proper coordination of

equipment support provisions and installation.

4. Install equipment giving right-of-way to piping systems installed at a required slope.

5. Install isolation valves and unions or flanges on the upstream and downstream side of each piece of equipment arranged to allow servicing, maintenance, and equipment removal without system shutdown.

D. Piping

1. Install piping approximately as shown on the bid set drawings, or as shown in approved shop drawings.

2. Piping shall be installed as straight and direct as possible, and be neatly spaced to allow min. 1" clearance between pipe and all other materials.

3. All piping shall be pitched to ensure proper drainage – per NFPA 13. Provide auxiliary drains per NFPA 13 at all low points making it possible to drain the water from all piping systems without cutting the pipe.

4. If temperature swings shall exceed 40 degrees F, provide swing joints to allow for expansion and contraction. Anchor piping to ensure proper direction of expansion and contraction.

5. Cut pipe square and to exact lengths. Re-cut any pipe that is accidentally cut shorter or longer than required.

6. Install branch connections to mains using tee fittings in main. Where space permits, takeoff shall come out the top or side of the main.

7. Install dielectric nipples or insulating flange gaskets, anywhere piping of dissimilar metals is joined.

8. Threaded pipe: Apply appropriate tape or thread compound to the external pipe threads. Assemble joint wrench tight.

   a. Small fittings shall be taper thread.

   b. Screwed pipe shall be reamed smooth before installation.

   c. Not more than three threads shall remain exposed outside each fitting after the joint has been made up.

   d. Each length of pipe shall be hammered and all scale shall be blown out before assembling.

   e. Threaded joints shall not be caulked to prevent or stop leaks.

9. Testing: Test all FP pipe with water to 200 psi. Piping shall hold pressure for 2 hours with no drop in pressure. All piping pressure tests to be witnessed by the engineer or Authority Having Jurisdiction (AHJ).

10. Piping or other apparatus shall not be installed in such a manner as to interfere with the full swing of the doors and access to other equipment.

11. Change pipe sizes with reducing fittings. Bushings shall not be allowed unless specifically approved.

12. Any piece of pipe six inches or less in length shall be considered a nipple.

E. Valves

1. Provide a union, grooved-fitting, or bolted-fitting connection within approximately 12" of each valve.

2. Examine valve interior and threads for cleanliness and form. Do not attempt to repair defective valves; replace with new valves.

3. Locate valves for easy access and provide separate support where necessary.

4. Install valves in a position to allow full stem movement. Where possible, install valves with the stem at or above the center of horizontal pipe.

5. Adjust or replace any leaking valve packing after piping systems have been tested and put into service. Replace valves if leak persists.

6. Location of Valves: Install valves where indicated on the drawings and as follows:

   a. At building service entrance,
   b. Base of all risers,
   c. On the upstream and downstream side of the backflow preventor.
   d. At all zone-control valve stations
   e. At all drain points draining over 5 gallons.

7. Valves shall be located to permit easy operation, replacement or repair.

F. Sleeves and Escutcheons

1. Sleeves

   a. In finished areas where pipe is exposed, install sleeves flush with the finish floor,

   b. In chases, mechanical rooms, and janitor's closets extend sleeves at least 4 inches above finish floor.

   c. Sleeves through interior masonry or non-masonry walls or partitions shall be set flush with the finished surfaces of the wall or partition.

   d. Make pipe penetrations watertight where passing through exterior walls, slabs on grade and over crawl spaces, and waterproofed floors.

   e. Provide an airtight acoustical barrier where pipes / sleeves pass through floors, walls, and ceilings of noisy spaces, such as mechanical rooms, music rooms, gymnasiums, cafeterias, auditoriums, and corridors.

f. Provide an airtight acoustical barrier where pipes / sleeves pass thru floors, walls, and ceilings of quiet spaces, such as classrooms, offices, the media center.

2. Escutcheons

a. Escutcheons shall be installed around all exposed pipe passing through a finished floor, wall or ceiling. Escutcheons shall fit snugly around the bare pipe.

b. Escutcheons shall be installed around all sprinklers (except concealed pendants) penetrating a ceiling.

c. Escutcheons shall completely cover the hole for a neat and finished look.

G. Hangers

1. All piping and equipment shall be supported from the building structure - beams, bar-joists, concrete walls and decks, wall studs, etc. Nothing shall be supported by the metal roof deck, other piping, ductwork, conduit, ceiling suspension, or framed-wall sheathing. Support shall be by means of approved hangers and supports, so arranged as to provide for expansion and contraction.

2. Hanger locations: Provide hangers:

a. Per the maximum o.c. spacing shown on the drawings hanger schedule.
b. Within two feet of all changes in direction (horizontal and vertical)
c. On both sides of concentrated loads independent of the piping.
d. Within 2' of each equipment connection, to eliminate strain on connection points
e. Hangers near equipment shall permit the removal of equipment, valves and accessories with a minimum of dismantling and without requiring additional pipe support after these items are removed.

3. Hangers shall be located and adjusted to distribute loads equally on attachments, maintain proper pitching of pipe, and to prevent vibration and to secure piping in place.

a. Pipe pitch shall *not* be achieved by shims or other non-approved methods.

4. Vertical risers shall be firmly supported by riser clamps, properly installed to relieve all weight from the fittings.

a. All vertical pipe shall also be supported at its base.

b. Friction clamps installed above floor slabs shall not be supported from or rest only on floor sleeves.

5. Each Trade-contractor shall provide all necessary structural steel required to firmly and substantially support their equipment and distribution systems.

a. Structural steel and hardware shall conform to standard ASTM

specifications

b. All supplementary steel, including factory fabricated channels and associated accessories shall be subject to the approval of the Engineer.

6. Installation of hangers which permit wide lateral motions of any pipe shall not be acceptable.

a. Vertical hanger rods to support piping from the structure or supplementary steel shall not exceed four feet in total length.

b. Piping with over 14" of lateral movement shall be braced to prevent such movement.

7. Where piping is supported from beams, support parallel pipes from different beams.

a. Retaining straps shall be provided with all beam clamps.

3.6 ADJUSTMENTS AND FIELD CHANGES

A. Where additional offsets must be added to the FP piping to coordinate with other work (beyond those shown in the contract documents), 45 degree elbows shall be used to minimize additional pressure drop. Locations where the trade contractor considers 45 degree offsets "impractical" shall be reviewed by the Engineer on a case by case basis.

B. After completion of the installation work and equipment start-ups, perform the necessary adjustments to systems installed under this Section. Submit verification that systems can be fully drained, and will operate as intended.

3.7 PIPE APPLICATIONS

A. Install Schedule 40 steel pipe with threaded joints or roll-grooved ends with grooved mechanical couplings..

B. Install Schedule 10 steel pipe only for pipe 2-1/2" and larger, with roll-grooved ends and grooved mechanical couplings.

3.8 FIRE PROTECTION PIPING INSTALLATIONS

A. Locations and Arrangements: So far as practical, install piping as indicated by approved "Shop Drawings".

B. Coordinate "Shop Drawings" with other trades – do not run FP piping over any electrical or control panels. Adjust routing and sprinkler locations as required to avoid obstructions to sprinkler spray.

C. All piping passing thru exterior walls (FDCs and Drains) shall be galvanized, and air and water sealed by the FP trade contractor to sleeves (or cored hole) on both the interior and exterior sides. Sealing of sleeves to building is by Building trades in addition to FP sealing. Sealing of escutcheons to the exterior wall is not an acceptable

alternative to sealing pipes to sleeves and sleeves to cored wall.

D. Run all piping as high as possible – a minimum of 6" above the top of ceiling grids. Locations where the trade contractor believes piping must be run lower than this will be reviewed on a case by case basis by the Architect and Engineer of Record.

E. Where sprinklers are required at the deck level and also below large ducts (in the same space), branches shall be coordinated to run above the top of the ducts.

F. All run-outs and drops to individual sprinklers are 1" unless noted otherwise. Riser nipples to single branches shall be branch size, and one size larger than branch size if feeding 2 equal size branches.

G. Where flexible sprinkler head connectors are used, comply with both UL and FM limits for maximum elbows and minimum bend radius.

1. Provide a pre-printed label on each flexible connector anchoring component, limiting the re-location of the sprinkler – see NFPA 13 2013 9.2.1.3.3.4 for suggested text

H. Grooved pipe couplings listed as "flexible" couplings shall be provided at the top and bottom of each riser (below the 4-way bracing), within 24" of building expansion joints (one side only), Grooved-pipe couplings not specified as "flexible" shall be "rigid" type.

I. Install flanged or grooved fittings on valves, apparatus, and equipment having 2-1/2 inch and larger connections.

J. Hangers and Supports: Comply with the requirements of NFPA 13, with the following additional criteria from the structural engineer of record.

1. This trade contractor shall refer to "TYPICAL HANGER LOAD RESTRICTIONS at COMPOSITE SLABS and ROOF DECK" on drawing S1.03 for the following information:

a. Hanger load limitations including associated pipe sizes.

b. Metal roof deck notes.

c. The structural engineer's concern is continuous, actual loads. Maximum continuous load per deck-attached hanger shall be 100 lbs for all piping including FP. The NFPA 13, requirement to include a 250 lb "additional potential load" in sizing hangers shall not be considered in determining FP deck-hanging limitations.

2. This trade contractor shall design, furnish, and install all supplementary steel or Unistrut systems which shall be supported only by structural steel when hanger loads exceed limitations set forth in detail "TYPICAL HANGER LOAD RESTRICTIONS at COMPOSITE SLABS and ROOF DECK" on drawing S1.03.

3. "Sammy" hanger attachments are not permitted under any conditions.

4. All FP piping 4” and over shall be hung from structural steel.

K. Seismic Bracing and restraint: Provide protection from earthquake damage in accordance with NFPA 13. Braces and restraints must be installed prior to the ceiling installation in that area. Mee the following additional criteria from the structural engineer of record.

1. All FP seismic braces shall be attached to structural steel – no attachments to concrete-filled steel decks permitted.

2. End-of-line and intermediate lateral restraints installed on pipe 2” and under may be attached to concrete-filled decks, within the same load limitations noted above for hangers, and as shown on the structural detail, “Typical Hanger Load Restrictions at Composite Concrete Slab on Deck” – shown on drawing S1.03.

3. All C-clamp type fasteners for pipe hangers and restraints shall have a retaining strap. C-clamp type fasteners only permitted for seismic restraint if part of a listed system.

4. All mains and cross mains (regardless of size) and all branch piping 2-1/2" or larger shall be braced longitudinally within 40 ft. of the end of line (EOL) and max. 80' o.c. from there on.

5. Where hanger rods are more than 6" from the attachment to building structure to top of pipe, lateral bracing shall also be installed – within 6 ft of the EOL, and max. 40' o.c. from there on.

6. 4 way braces shall be installed at the top of each riser, and within 6’ on both sides of seismic separation assemblies.

7. Provide vertical and lateral restraint per NFPA 13, for all branches carrying 2 or more sprinklers.

L. Make connections between underground and above-ground piping using an approved transition piece strapped or fastened to prevent separation.

M. Test and Drains: Install test connections sized and located in accordance with NFPA 13 complete with shutoff valve. Test connections may also serve as drain pipes.

N. Pressure Gages:

1. Pressure gauges shall be installed in such a manner as to cause a minimum restriction to the flow in the pipes and so that they can be easily read from the floor.

2. Install valved-pressure gage on:

a. the service entrance (before the back-flow)
b. the riser or feed main (after the riser check valve)
c. at or near each test connection.
d. On both sides of each zone-control station control valve.
e. At the top of each standpipe (or roof hydrant if standpipe extends to hydrant)

3. Provide gage with a connection not less than 1/4 inch and having a ¼-turn valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and where they will not be subject to freezing.

O. Flow and Tamper Switches shall be furnished and mechanically installed by the fire protection Trade-contractor. All wiring shall be done under Division 28.- Fire Alarm.

3.9 PIPE JOINT CONSTRUCTION

A. End Treatment: After cutting pipe lengths, remove burrs and fins from pipe ends.

B. Welded Joints: AWS D10.9, Level AR-3.

C. Threaded Joints: Conform to ANSI B1.20.1, tapered pipe threads for field cut threads. Join pipe, fittings, and valves as follows:

1. Note the internal length of threads in fittings or valve ends, and proximity of internal seat or wall, to determine how far pipe should be threaded into joint.

2. Align threads at point of assembly.

3. Apply appropriate tape or thread compound to the external pipe threads.

4. Assemble joint to appropriate thread depth. When using a wrench on valves, place the wrench on the valve end into which the pipe is being threaded.

5. Damaged Threads: Do no use pipe with threads which are corroded, or damaged. If a weld opens during cutting or threading operations, that portion of pipe shall not be used.

D. Flanged Joints: Align flanges surfaces parallel. Assemble joints by sequencing bolt tightening to make initial contact of flanges and gaskets as flat and parallel as possible. Use suitable lubricants on bolt threads. Tighten bolts gradually and uniformly to appropriate torque specified by the bolt manufacturer.

E. Mechanical Grooved Joints: Roll grooves on pipe ends dimensionally compatible with the couplings. No cut grooves permitted.

F. Brazed Joints: Comply with the procedures contained in the AWS “Brazing Manual.”

a. WARNING: Some filler metals contain compounds which produce highly toxic fumes when heated. Avoid breathing fumes. Provide adequate ventilation.

G. Soldered Joints: Comply with the procedures contained in the Copper Development Association “Handbook for Fire Sprinkler Systems.”

3.10 VALVE INSTALLATION

A. General: Install fire protection specialty valves, fittings, and specialties in accordance with the manufacturer’s written instructions, NFPA 13, and the authority having jurisdiction. All valves shall be line size.

B. Install supervised-open valves to control all sources of water supply except fire department connections. Where there is more than one control valve, provide permanently marked identification signs indicating the portion of the system controlled by each valve.

1.

C. Install check valves in each water supply connection, each FDC connection, and each zone control valve station. .

D. Alarm Check Valves: Install valves in the vertical position, in proper direction of flow including the bypass check valve and retard chamber drain line connection. Install valve trim in accordance with the valve manufacturer's appropriate trim diagram. Test valve for proper operation.

E. Install Hose valves centered in hose cabinets, with valve outlet angled down approximately 30 degrees. Where 26x26 cabinet is specified, installation should allow a 12" spanner wrench to be turned 250 degrees. Hose valve nipple may enter from the side, top, or bottom of cabinet.

3.11 SPRINKLER HEAD INSTALLATIONS

A. Extended Coverage sprinklers: ¾" and 1" sprinkler outlets shall be color coded with spray paint at rough-in – to permit verification from the floor that the proper size outlet has been installed.

B. Some specified sprinkler types / temperature ratings may be less readily available than other types. The contractor shall inquire about all sprinkler lead times a minimum of 3 months before needing to order those sprinklers, to ensure the specified temperature ratings can be obtained.

C. All pendant sprinkler locations shown on the drawings have been carefully coordinated by the Architect for aesthetics and to avoid conflicts with other trades. Locations shall not be changed without written approval of both the Architect and the FP Engineer of Record. If layout shown must be modified to provide proper sprinkler coverage per code, notify the Engineer of Record immediately in writing

1. Exposed Upright sprinkler layouts may be modified by the FP trade contractor, who must then also coordinate the revised layout with other trades, and provide a calculation to show the revised layout works hydraulically.

D. All ceiling-sprinklers in square ceiling tiles shall be centered in all directions, unless specifically shown otherwise. All sprinklers in rectangular-ceiling tiles shall be centered as shown on the drawings.

E. Concealed pendant sprinkler caps shall not be installed until the ceiling tile at that sprinkler has been installed.

F. Use proper tools to prevent damage during installations.

G. All exposed sprinklers in areas to be painted shall be protected with factory caps, or by completely wrapping the sprinkler, to prevent paint-over-spray from contacting any

sprinklers. If any sprinklers are painted as a result of not being properly protected, or being prematurely uncovered, the FP trade contractor shall replace those sprinklers with no additional cost to the owner.

H. Use proper length nipples, to provide minimum required clearance from ceilings, and near-by obstructions. Install all uprights as close to the deck as possible, without being obstructed by adjacent construction. Where roof deck corrugations are over 3" deep, sprinkler distance below deck is measured to high point of deck.

I. Provide escutcheon's that completely cover ceiling openings, and sprinkler frame.

J. Dry sprinklers: Provide minimum length of dry sprinkler inside heated space per NFPA Table 8.4.9.1.a. for insulated walls. For non-insulated walls, provide minimum 18" length of dry sprinkler inside heated space.

1. For sprinklers extending outside the building, use outside temperatures of -10, and above ceiling temperatures of 45 F .

2. For sprinklers extending into walk-in coolers / freezers, use the cooler temperature, and above-ceiling temperature of 45 F.

K. Sprinkler temperature ratings shall be per NFPA 13: including (but not limited to):

1. Intermediate temperature through-out, except where high temperature are required by code.

2. High temperature: within 7 ft of heating equipment pressure relief valves; within 7 ft of unit heater discharge; around commercial kitchen cooking equipment, and over extra hazard spaces

L. Provide sprinkler guards for all upright sprinklers in all gyms, weight room, wellness center, mechanical spaces, under stairs, under open-joist mezzanines, in storage rooms, and where exposed and located less than 15 ft above the floor.

M. Install dry sprinklers in the 1" NPT outlet or run of a threaded Tee fitting. Do not install in a threaded elbow.

N. Upright sprinklers – install as close to the deck as possible, without sprinkler spray being obstructed.

3.12 FIRE DEPARTMENT CONNECTION INSTALLATIONS

A. Install automatic ball-drip valves at the check valve on the fire department connection to the mains. Pipe the drip valve outside the building, or to a floor or indirect drain, terminating below the strainer..

B. Install mechanical sleeve seal at pipe penetration in outside walls. Both sides of exterior wall penetration must be air and water sealed.

C. Install with centerline of FDC between 18" and 4' above grade. Install drains minimum 18" above grade.

3.13 BACKFLOW PREVENTER PERMIT AND INSTALLATION

A. All backflow prevention devices shall be approved, permitted, installed, maintained, and tested in accordance with the requirements of the State and the Local Water Authority.

B. Backflow preventer type, application, and installation shall comply with the Commonwealth of Massachusetts, Department of Environmental Protection (DEP) Drinking Water Regulations 310 CMR 22.00.

C. Prior to installation, the Trade-contractor shall submit a design data sheet, with plans showing the method of protecting the water system, and secure approval from the Local Water Authority, or its designee. This shall not be done until the Trade-contractor has secured the permit for the work, and shop drawings have been approved.

D. Mount backflow preventor horizontal and level, at heights and with clearances per DEP regulations.

1. Double check and Reduced pressure backflow preventers shall be installed between 36 inches to 48 inches above the floor with a minimum of 12 inches clear space from back wall and 3'0" in front.

2. Provide indirect waste piping with funnel to receive discharge from backflow preventer vents and spill through air gap into floor drain.

E. Immediately upon installation, the Trade-contractor shall have the backflow preventer tested by a "Certified Backflow Prevention Device Tester", and the results recorded on the Local Water Authority's Inspection and Maintenance Report Forms. Within 14 days after the installation, the Trade-contractor shall notify the reviewing authority to arrange inspection of the installation.

F. Three (3) copies of each application and all subsequent correspondence, including the final permit, shall be forwarded to the Designer for record. Availability of final approvals or permits shall be prerequisite to scheduling a final inspection of the fire protection work.

3.14 PAINTING AND FINISHING

A. Damage and Touch Up: After installation, equipment and accessories with factory primed or finished surfaces shall be cleaned, and thoroughly inspected by the Fire Protection Trade-contractor.

1. Repair marred or damaged factory-painted or galvanized finishes with materials and procedures to match original factory finish.

2. All items so repaired and refinished shall be brought to the attention of the Designer and Owner’s Project Manager for inspection and approval.

B. Materials and workmanship shall be equal to the requirements specified under Section 09 91 00 PAINTING.

C. Surfaces which will be inaccessible for painting after installation shall be painted before installation.

D. Surfaces to be painted shall be thoroughly cleaned of all scale, rust, dirt, oil and other foreign matter and shall be completely dry before applying paint.

E. Nameplates on all equipment shall be cleaned and left free of paint.

3.15 CLEAN-UP

A. At the end of each working day, the Fire Protection Trade-Contractor shall move all equipment, tools, and materials to the designated storage area, and leave all work areas in a reasonably clean condition.

B. Refer to section 01 73 00 for recycling and waste disposal requirements. Include any required costs in the bid price.

C. After completion of the work, all tools and other equipment shall be removed from the site. All excess materials shall be removed and the site left broom clean.

D. The Fire Protection-Trade-contractor shall thoroughly clean all piping and equipment inside and out before placing it in operation. All equipment, pipe, valves and fittings shall be cleaned of grease, metal cuttings and sludge which may have accumulated by operation of the system for testing.

E. If any part of a system should be stopped or damaged by any foreign matter after being placed in operation, the system shall be disconnected, cleaned, and reconnected by the installing contractor at no additional cost to the Owners.

3.16 SIGNAGE AND MAPS

A. Provide durable, permanently installed, readily visible from 10' away, and AHJ approved signs as follows .

1. "Building Sprinkler Control Valves" in 2-1/2" high letters on all valve-room doors.

2. "Auto Stdpipe / Sprinkler" in 1" high letters on all sprinkler fire dept. connections .

3. "Test and drain" and in 1" high letters on all main and auxiliary drains.

4. “Control Valve” and “for (area served)” on all control valves.

5. “Dry Valve” for all dry system riser valves.

6. Outside audible alarms – see wording per NFPA 13 2013 8.17.1

7. General Information Sign – per NFPA 13 2013

B. Provide color coded sprinkler zone maps and auxiliary drain maps.

1. Auxiliary drain maps:

a. Provide floor plans (with room outlines and numbers) of each riser / ZCV’s

service area (including the dry-system risers), showing the location of all auxiliary drains. The area drained by each auxiliary drain (after the ZCV drain has fully drained what it can drain) shall be colored in a different, distinct color.

b. Provide an 8x11, laminated copy of the drain maps permanently attached to their respective zone-control valve station.

2. Sprinkler zoning:

a. Provide floor plans (with room outlines and numbers) of each riser / Zone-Control-Valve's service area, showing the location of the ZCV. The area served by each ZCV shall be colored in a different, distinct color.

b. Provide an 8x11, laminated copy of the floor plans permanently attached to the associated zone-control valve station.

c. Provide a full size, framed under plexi-glass zoning maps – located as directed by the local fire dept

C. List of spare sprinklers in spare sprinkler cabinet, with type, SIN, temperature rating, K-factor, and general description of the area where each sprinkler is used, such as "offices and classrooms", "gym", "walk-in-coolers".

D. "Design hydraulics summary on each combination standpipe-sprinkler riser Zone Control Valve Station Include:

a. Location / description of area(s) calculated
b. Number of sprinklers calculated.
c. flow test gpm and pressures,
d. design gpm and pressure.

3.17 TESTING AND FLUSHING

A. Flush, test, and inspect all FP piping installed by this contractor.

1. This Trade-contractor shall notify the Designer, Owner's Project Manager and all AHJs, a minimum of 1 week in advance of flushing or any required tests, so they may be present to witness the tests

2. All flushing and testing shall be witnessed by the construction manager, the Owner's Project manager, all AHJs.

B. Assist Fire Alarm trade contractor in the testing of all FP flow switches, pressure switches, , flow alarms and tamper switches, Clean Agent system alarms, troubles, and supervisory signals, and Fire Command Center valve and water flow detector display panel signals. All device testing to be witnessed by the Engineer of Record.

1. Successful F/A testing of all FP trouble and alarm devices is a pre-requisite to FP substantial completion.

2. Successful F/A testing of all FP trouble and alarm devices shall be repeated 1

year after substantial completion, and is a pre-requisite to ending the warranty period.

3. All Devices shall be individually tested, including (but necessarily limited to):

   a. FP Service room - Backflow control valve tamper switches (Qty 2)
   b. FP Service room – Main flow switch
   c. FDC – front main entrance – electric bell
   d. FDC – rear main entrance – electric bell
   e. Standpipe Riser control valve tamper switches (8 total)
   f. Wet Sprinkler Zone Control Valve Station control valve tampers (15 total)
   g. Wet Sprinkler Zone control Valve station flow switches (15 total)
   h. Dry system control valve tampers (2 total)
   i. Dry system flow pressure switches (2 total)
   j. Dry System high-low-air pressure supervisory (2 total).
   k. Clean agent system – complete sequence of operations including smoke detector actuation, manual pull station actuation, manual abort actuation, releasing device actuation
   l. Stage Hose Valve feed Control Valve tamper switch
   m. Stage Hose Valve feed Flow switch
   n. Clean Agent System Control panel monitoring of all devices including Alarm module, Trouble Module, Supervisory Module
   o. Each input to the Fire command Center “Valve and water-flow detector” display panels.

C. Test the un-boosted, available flow and pressure from all roof hydrants with the Fire Dept. Coordinate directly with the Fire Dept. for scheduling and test procedures.

D. Inspect the installation of, and witness the flushing and testing of all FP-only underground piping installed by the site contractor (site contractor to perform actual underground flushing and pressure testing.). Provide a NFPA 13 underground test and materials certificate based on witnessing the work..

1. General Contractor shall certify that the site contractor has thoroughly flushed the main underground loop per the following criteria prior to flushing the FP-only service line:

2. All main underground loop piping shall be flushed out an open, 4” hydrant butt, or maximum-15’-long, 4” hose, Flush out of the hydrant closest to the mid-point of the loop.

3. 1 side of the main underground loop piping shall be flushed at a time, to ensure maximum water velocity thru that half-loop.

4. Flush for a minimum of 30 seconds per 100 ft of underground pipe.

E. Flushing FP-only service line into building:

1. The FP service line shall be flushed out a hose manifold that provides a combined, minimum 45 square inches of free-cross-sectional area. Options include:

   a. 3, 4” hoses
   b. 7, 3” hoses

c. 10, 2-1/2" hoses.

2. Maximum length per hose: 50 ft.

3. Flush for a minimum of 30 seconds per 100 ft of FP-only underground length.

F. Flush, test, and inspect interior systems in accordance with NFPA 13 and the State Building Code. All labor, materials, instruments, devices and power required for testing and flushing shall be provided by this Trade-contractor.

1. Prior to testing, the system shall be thoroughly flushed with clean water.

2. Flushing and pressure testing shall be performed in the presence of the Designer or Owner's Project Manager and such other Authorities Having (legal) Jurisdiction (AHJs).

3. No piping in any location shall be closed up, furred in, or covered before testing and approval by the Local AHJ and Owner's Project Manager. Where portions of piping systems are to be covered or concealed before completion of the project, those portions shall be tested separately in the manner specified for the entire system.

G. Test Criteria: -

1. Piping shall be pressure tested, and when directed by the Designer, Local Fire Department or Owner's Project Manager shall be tested for stability of support.

H. Test Procedures:

1. Test piping prior to installation of ceilings, to permit easy inspection of all joints.

2. Subject piping to a two-hour water-pressure test at 200 psi for 2 hours with no drop in pressure. per NFPA and the User Agency's Insurance Underwriter. Air-pressure test is not an acceptable substitute. Piping shall be repaired until such tests show no drop in pressure. Where required, and depending on the building timing and schedule, the system may be required to be tested without final swing elbows and heads installed. In this case, a second test shall be required upon installation of swing elbows and heads.

3. Results of tests shall be recorded and submitted using the forms in NFPA #13, for review by the Engineer. The Material and Test Certificate shall also be sent to the Owner's Project Manager and User Agency's Insurance Underwriter.

4. Material and test certificates must be signed by the Owner's Project Manager prior to and upon completion of testing. Final test reports must be approved in writing by local authorities.

5. This Trade-contractor shall ensure that the FP-only underground piping from the site loop to the FP service has been tested to 200 psig for 2 hours in accordance with NFPA 24 requirements. This shall be recorded separately from the interior piping. Coordinate this with the site water piping installer.

I. Failed Tests, Re-testing, and Damage Caused by Testing:

1. Repair, or if directed by the Fire Protection Engineer of Record or Owner's Project Manager, replace any defective work with new work without extra cost to the Owner or Engineer. Repeat tests until the work is proven to meet the requirements specified herein.

2. Caulking of screwed joints or holes in piping shall not be acceptable.

3. Any piping or equipment that has been left unprotected and subject to mechanical or other injury in the opinion of Owner's Project Manager shall be retested.

4. Restore to its finished condition any work, provided by other Contractors, damaged or disturbed by tests. The Fire Protection Trade-contractor shall engage the original Contractor to do the work of restoration to the damaged or disturbed work.

J. Testing with Other Systems:

1. Provide all necessary and appropriate personnel to participate in and coordinate fire protection systems with all fire alarm testing, or other systems testing which may interface with fire protection system.

2. Participation shall include all preliminary testing prior to official testing, and any re-testing if required.

3.18 INSPECTION OF WORK

A. The Fire Protection Engineer of Record will be checking the completed work each month, sequentially as different phases are completed. A field report will be issued for each inspection, which will include a list of punch items identified to date.

1. Above-ceiling punch items for each phase shall all be completed, and the engineer of record shall be notified punch items are complete prior to the "flooding" of ceiling tiles for that phase. NOTE: FP work that is incomplete because another trade must complete their work first will be shown on the punch drawings, but is not be considered a "punch item". It is simply incomplete.

2. The fire-protection contractor shall notify the engineer in writing when all punch items are believed to be complete.

3. If the engineer identifies punch items still not completed, the contractor shall have a qualified installer accompany the engineer on all subsequent inspections, to ensure that all remaining issues are fully understood as to location and work required. The installer shall provide, carry, and set-up any ladders required to view outstanding items.

4. All punch items must be satisfactorily completed prior to final payment for each phase.

B. Each phase will have it's own final inspection. There will also be a "final, final" inspection of the project in it's entirety at the completion of all work. Prior to any of the final inspections, the Fire Protection Trade-Contractor shall submit a letter signed by an officer of the company stating that:

1. he is an officer of the company,

2. he has personally inspected the installation to be checked,

3. the date of his inspection,

4. the installation is complete and tested and ready for final inspection by the Fire Protection Engineer of Record, and that all required test reports have been submitted.

3.19 SPARE STOCK

A. Provide Spare-Sprinkler Cabinets with spare sprinkler heads of each type, K-factor, and temperature rating on the project. Include in each cabinet, a typed, laminated list of the spare sprinklers in that cabinet, including sprinkler type and SIN, K-factor, temperature rating, and locations they are used.

1. Quantities of spare head required is as follows:

a. Provide 3 spares of each head type used in any Extra Hazard space.
b. Provide 2 spares of each sprinkler type used only in Light or Ordinary hazard spaces.

c. Where 3 or fewer of a particular sprinkler type is installed – provide 1 spare

2. Group sprinklers within cabinets by sprinkler type / location, and label the panel door, to make finding a particular sprinkler easier.

a. Specialty sprinklers – such as under-bleacher, under cloud sprinklers.
b. Concealed pendants (EC and SS)
c. Uprights (EC and SS)

END OF SECTION

SECTION 22 00 00

PLUMBING

(Trade Contract Required)

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PART 1 - GENERAL

1.1 PUBLICLY BID TRADE CONTRACTOR

A. Sub-bids for work under this Section shall be for the complete work and shall be filed in a sealed envelope with the City of Worcester, Department of Public Works and Parks, 50 Officer Manny Familia Way (formerly Skyline Drive), Worcester, MA 01605 at time and place stipulated in the “Invitation to Bid/Notice to Contractors”. The following shall appear on the upper left hand of the envelope:

Name of Sub-Bidder: *Print Name of Sub-bidder*

Project: DOHERTY MEMORIAL HIGH SCHOOL

Sub-Bid for Section: 22 00 00 - PLUMBING

B. Each sub-bid submitted for work under this Section shall be on forms furnished by the City of Worcester as required by Section 44F of Chapter 149 of the General Laws, as amended. Sub-Bid forms may be obtained at the Department of Public Works and Parks, 50 Officer Manny Familia Way (formerly Skyline Drive), Worcester, MA 01605 in person, or by written request.

C. Sub-bids filed with the City of Worcester shall be accompanied by a BID BOND or CASH or CERTIFIED CHECK or a TREASURER’S or CASHIER’S CHECK issued by a responsible

bank or trust company payable to the City of Worcester in the amount of five (5) percent of the bid. A sub-bid accompanied by any other form of bid deposit than those specified will be rejected.

D. Additional Requirements:

1. Sub-bidder's attention is directed to Massachusetts G.L. Chapter 149 §44H, as amended, which provides in part as follows:
2. Each sub-bidder shall list in Paragraph E of the "Form for Sub-bids" the name and bid price of each person, firm or corporation performing each class of work or part thereof for which the Section of the Specifications for that sub-subtrade requires such listing, provided that, in the absence of a contrary provision in the Specifications, any sub-bidder may, without listing any bid price, list his own name or part thereof and perform that work with persons on his own payroll, if such sub-bidders, after sub-bid openings, shows to the satisfaction of the Awarding Authority that he does customarily perform such class of work with persons on his own payroll and is qualified to do so. This Section of the Specifications requires that the following classes of work shall be listed in Paragraph E under the conditions indicated herein.
   Sub-Subs required:

Class of Work	Reference Spec.	Paragraphs
Insulation	22 00 00	2.10; 3.14; 3.32

E. The work to be completed by the Trade Contractor for the work of this Section is shown on the following listed Drawings, not just those pertaining particularly to this Trade Contract, unless specifically called out otherwise, regardless of where among the Drawings it appears:

1. The Work of this Trade Contract is shown on the following Drawings:
   P2.1, 2.2, P2.3, P2.4, P3.1, P3.2, P3.3, P3.4, P3.5, P3.6, P3.7, P3.8, P3.9, P3.10, P3.11, P3.12, P3.13, P3.14, P3.15, P3.16, P3.17, P3.18, P3.19, P3.20, P3.21, P4.1, P4.2, P4.3, P4.4, P4.5, P4.6, P4.7, P4.8, P4.9, P4.10, P4.11.
2. Related items which may require coordination or impact work of this trade are shown on the following Drawings:
   EX1.0, EX2.0, EX3.0, EX4.0, C1.0, C1.1, C1.2, C2.0, C2.1, C2.2, C3.0, C3.1, C3.2, C4.0, C4.1, C4.2, C5.0, C5.1, C5.2, C6.0, C6.1, C6.2, C6.3, C7.0, C7.1 C7.2, C8.0, C8.1, C8.2, C9.0, C9.1, C9.2, C9.3, C10.0, C10.1, C10.2, C10.3, C10.4, C10.5, L0.0, L0.1, L0.2, L1.1, L1.2, L1.3, L1.4, L1.5, L2.1, L2.2, L2.3, L2.4, L2.5, L2.6, L3.1, L3.2, L3.3, L3.4, L3.5, L4.1, L4.2, L4.3, L4.4, L4.5, L4.6, L4.7, IR-1, IR-2, IR-3, S1.01, S1.02, S1.03, S3.01, S3.02, S3.03, S3.04, S3.05, S3.06, S3.07, S3.08, S3.09, S3.10, S3.11, S3.12, S3.13, S3.14, S3.15, S3.16, S3.17, S3.18, S3.19, S3.20, S3.21, S3.22, S4.01, S4.02, S4.03, S4.04, S4.05, S4.06, S4.07, S4.08, S4.09, S4.10, S4.11, S4.12, S4.13, S4.14, S4.15, S4.16, S4.17, S4.18, S4.19, S4.20, S4.21, S4.22, S4.23, S4.24, S4.25, S4.26, S4.27, S4.50, S4.51, S4.52, S4.53, S4.54, S4.55, S5.01, S5.02, S5.03, S5.04, S5.11, S5.12, S5.13, S5.14, S5.15, S5.16, S5.17, S5.18, S5.19, S5.20, S6.01, S7.01, S7.02, AD1.0, A1.0, A1.1, A1.2, A1.3, A1.4, A1.5, A1.6, A1.7, A2.0, A2.1, A2.2, A2.3, A2.4, A2.5, A2.6, A3.1, A3.2, A3.3, A3.4, A3.5, A3.6, A3.7, A3.8, A3.9, A3.10, A3.11, A3.12, A3.13, A3.14, A3.15, A3.16, A3.17, A3.18, A3.19, A3.20, A3.21, A3.22, A4.1, A4.2, A4.3, A4.4, A4.5, A4.6, A4.7, A4.8, A4.9, A4.10, A4.11, A4.12, A4.13, A4.14, A4.15, A4.16, A4.17, A5.0, A5.1, A5.2, A5.3, A5.4, A5.5, A5.6, A5.7, A5.8, A5.10, A5.11, A5.12, A5.13, A5.14, A5.15, A6.1, A6.2, A6.3, A6.4, A6.5, A6.6, A6.7, A6.8, A6.9, A6.10, A6.11, A6.12, A6.13, A6.14, A6.15, A6.16, A6.17, A6.18, A6.20, A6.21, A6.22, A6.23, A6.24, A6.25, A6.26, A6.27, A6.28, A6.29, A6.30, A6.32, A6.33, A7.0, A7.1, A7.2, A7.3, A7.4, A7.5, A7.6, A7.7, A7.8, A7.9, A7.10, A7.11, A7.12, A7.13, A8.1, A8.2, A8.3, A8.4, A8.5, A8.6, A8.7, A8.8, A8.9, A8.10, A8.11, A8.12, A8.13, A8.14, A8.15, A8.16, A8.17, A8.18, A8.18a, A8.19, A8.20, A8.21, A8.22, A8.22a, A8.23, A8.23a, A8.24, A8.24a, A8.25, A8.26, A8.27, A8.28, A8.30, A8.31, A8.32, A8.33, A8.34, A8.35, A8.36, A8.37, A8.38,

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3. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the documents identified in Division 00 Procurement and Contracting Requirements and Division 01 General Requirements.

4. The complete List of Drawings for the Project is provided in Section 00 01 15 – LIST OF DRAWINGS.

5. Examine all Drawings and all other Sections of the Specifications for requirements therein affecting the work of this Section The listing of Contract Drawings above does not limit Trade Contractor's responsibility to determine full extent of work of this Section by all Drawings listed in the Drawing List on the Drawing Title Sheet, as modified by Addenda.

1.2 SCOPE

A. Perform work and provide material and equipment as required for a complete and operational plumbing system as shown on the Drawings and as specified in this Section. Completely coordinate with work of other trades and provide for complete and fully functional installation.

B. The work shall include, but is not limited to, the following major items of work:

1. Sanitary waste and vent systems within the building to 10 ft. 0 in. outside the building installed with all incidentals necessary for a complete operational system. The system shall include all piping, traps, flanges, seals, cleanouts, structural support (carriers, hangers), roof terminals, fixtures, floor drains and such other standard accessories as are necessary for a complete approved system.

2. Garage waste and vent systems within the building to gas/sand trap inside and/or outside the building installed with all incidentals necessary for a complete operational system. The system shall include all piping, traps, flanges, seals, cleanouts, structural support (carriers, hangers), roof terminals, trench drains, floor drains and such other standard accessories as are necessary for a complete approved system. Exterior gas/sand trap is furnished and installed by the Site Contractor but piped by the Plumbing Contractor. Interior gas/sand trap is furnished and installed by the Plumber. Note that there are two garage waste and vent systems shown for this project with two gas/sand traps.

   a. These systems will also serve the two (2) elevator sump pump discharges. These piping connections are necessary in lieu of individual oil interceptors in the building. The elevator sump pumps consist of an automatic sump pump and fiberglass tank located outside of the elevator shaft and piped to the elevator sump. There will be a high water alarm for each of the sump pump basins.

3. Grease waste and vent system within the building to exterior grease interceptor inlet and outlet installed with all incidentals necessary for a complete operational system. The system shall include all piping (especially sanitary tees within grease interceptor), traps, flanges, seals, cleanouts, structural support (carriers, hangers), roof terminals, fixtures, floor drains, floor sinks, interior grease interceptor with flow control fitting, floor access panel for flow control valve and such other standard accessories as are necessary for a complete approved system. The exterior grease interceptor is furnished and installed by the Site Contractor but piped by the Plumbing Contractor.

4. Storm drainage system within the building to 10 ft. 0 in. outside the building installed with all incidentals necessary for a complete operational system. The system shall include all roof drains with primary and overflow drains, emergency overflow terminations (i.e. downspout nozzles), piping, traps, flanges, seals, cleanouts, structural support (hangers), insulation, and such other standard accessories as are necessary for a complete approved system. New roof drains and emergency roof drains shall be furnished and installed by the Plumbing Subcontractor. The canopy primary roof drains will require freeze protection electric heat trace.

5. Cold water system connecting each and every fixture, device, and item of equipment requiring cold water within the building including the water service entrance. The system shall be installed with all incidentals necessary for a complete operational system and shall include all piping, pressure reducing valves, insulation, valves, stops, hydrants, backflow preventers, vacuum breakers, gauges, structural support (hangers), water hammer arresters, trap primer valves with air gap fittings, hose bibs, sillcocks, triplex variable speed packaged booster pumping system with hydro-pneumatic tank and such other standard or specified accessories as are necessary for a complete approved system. This Contractor’s work shall begin at flange provided by the Site Subcontractor.

6. Hot water system connecting each and every fixture, device, and item of equipment requiring hot water within the building. The system shall be installed with all incidentals

necessary for a complete operational system and shall include gas-fired hot-water boilers, storage tanks, electric water heaters, all piping, insulation, valves, stops, backflow preventers, vacuum breakers, gauges, recirculation pumps, tempering/mixing valves, structural support (hangers, etc.), water hammer arresters, thermometers and such other standard or specified accessories as are necessary for a complete approved system.

7. Tempered hot water system connecting each and every emergency fixture requiring tempered hot water within the building. The system shall be installed with all incidentals necessary for a complete operational system and shall include emergency plumbing fixtures, emergency thermostatic mixing valve, all piping, valves, gauges, recirculation pumps, structural support (hangers, etc.), thermometers, and such other standard or specified accessories as are necessary for a complete approved system. Tempered water recirculation lines will connect to the outlet of the emergency mixing valve. Note: since the water temperature in this system should be between 65˚F and 75˚F, no pipe insulation is required per the IECC.

8. Natural gas piping system connecting each and every fixture, device, and item of equipment requiring gas within the building from the outdoor gas meter. The system shall be installed with all incidentals necessary for a complete operational system and shall include all natural gas piping, valves, stops, drips, pressure reducing valves, vents to atmosphere from domestic water boilers and heating boilers (verify if required), gas regulators, gauges, structural support (hangers), science room gas turrets, science room emergency gas shut-offs and such other standard or specified accessories as are necessary for a complete approved system. Note that the entire system is low pressure gas.

    a. In kitchen, the gas piping has been removed. Therefore, there is no gas piping serving the kitchen.

9. Lab waste and vent system within the building as indicated on the Drawings. System shall be installed with all incidentals necessary for a complete operational system and shall include an active pH neutralizing system with a tank mounted in a pit with an FRP cover and grating, p-trap mounted after neutralizing tank with probe, chemical storage tanks with containment, pumps and mixers and interconnecting piping and wiring, pH monitoring system, all corrosion resistant piping, traps, running trap, shut-off valve, flanges, seals, cleanouts, structural supports (hangers), roof terminals, and such other standard accessories as are necessary for a complete approved system. Acid waste piping shall continue to 10 ft. 0 in. beyond the building foundation before connecting to the sanitary waste piping.

10. Compressed air system for the CCL Lab and ETA Shops connecting each and every air outlet to the compressed air system. The system shall be installed with all incidentals necessary for a complete operational system and shall include all compressed air piping, valves, filters, flexible connectors, quick-connect fittings, ceiling mounted air hose reels, air safety shut-off valves, electric drain valve, and such other standard accessories as are necessary for a complete approved system. The two (2) air compressors with integral air dryers and the air receiver tanks are furnished, installed and warrantied under the owners FF&E package.

11. Radon system connecting to the underground piping and rising through the building to a ventilation mast with two inline fans for each system (8 systems total). The systems shall be installed with all incidentals necessary for complete operational systems and shall include all perforated and solid PVC piping below grade, solid PVC piping above grade in

the building, stainless steel mast above the roof, radon fans (furnished by HVAC Contractor to Plumber for installation), guy wires, supports, and such other standard or specified accessories as are necessary for a complete approved system. The radon fans are wired by the Electrical Subcontractor. The radon fans are monitored and controlled by the HVAC controls subcontractor.

12. Plumbing Subcontractor (i.e. licensed gas-fitter) shall be responsible for furnishing and installing the flue and combustion air piping for the domestic hot water boilers. The HVAC Subcontractor shall be responsible for installing the flue for the heating boilers, but they shall be installed by a licensed gas-fitter on their staff and the HVAC Company shall have a gas-fitters license. Flues shall be installed with all incidentals necessary for a complete system in order for the domestic hot water boilers to operate properly and shall include all piping, drip legs, pipe tees for condensate collection, structural supports, and vent terminals per manufacturer's instructions. All flue and combustion air piping shall be labelled.

13. Provide all plumbing fixtures and equipment as required by drawings and as specified. All laboratory faucets and accessories (including gas turrets; dishwasher, refrigerator and ice maker connections) are by the Plumbing Subcontractor. All laboratory sinks are specified by the architect under laboratory casework. All fume hoods are by others and will have one integral cup sink, cold water only faucet and gas outlet.

14. All rough plumbing and final connections to all items of equipment furnished by others requiring water, gas, drain, and waste connections. Furnish and install all traps with cleanouts and heavy duty brass loose key angle valve supply stop kits. The plumbing contractor is responsible for installing kitchen equipment that requires plumbing. All floor drains and floor sinks must be coordinated with all kitchen equipment, toilet partitions and the flooring installer (i.e. ceramic tile – to be centered in the floor tile) for both functional performance and aesthetics display.

15. Furnish Access Panels to G.C. for installation by others.

16. Provide all Outdoor Restroom and Storage Building plumbing including fixtures, electric water heater, floor drains, hose bibs, domestic water service, oil interceptor and all other plumbing indicated. The plumbing systems shall be installed with all incidentals necessary for a complete operational system. The building is unheated and will be winterized. Slope all piping to low points and provide hose bibs or drain valves for draining or blowing out piping systems with compressed air.

17. The Plumbing Subcontractor shall be responsible for furnishing and installing all items in accordance with the National & Massachusetts Fuel Gas Code and Massachusetts State Plumbing Code. Plumbing fixtures and equipment shall be Massachusetts Plumbing Board Product Approved and shall have a product approval number.

18. This contractor shall be responsible for locating hangers (bang-it deck inserts) per the coordination process. Piping over 3" must be supported from the structure and not the composite concrete decking. Provide supplemental supports spanning between structural elements to support the piping. See section 2.11.L for additional information.

19. This Contractor shall be responsible for all seismic control for the entire plumbing piping system and equipment regardless of the code exception.

20. Fire-stopping of all rated wall, floor, and ceiling penetrations used by this trade-contractor for any work completed under this Section. See Section 07 84 13, Firestopping for required methods and procedures.

21. Walls requiring sound seal, noted w/ STC rating, including but not limited to: Classrooms, offices, media center, cafeteria, gymnasium, and music rooms (for sound control), and thru exterior walls (for water and air seal) to be sealed with non-combustible, water-proof material, as specified in Section 09 29 00 Gypsum Board, both sides of all penetrations.

22. Obtain all permits and approvals required for work under this Section.

C. Alternates: Special attention is called to the fact that it shall be the responsibility of all the General and Subcontractors to thoroughly examine all the alternates and evaluate for themselves as to whether or not these alternates in any way affect their respective section. In the event that a Contractor feels that any alternate(s) do reflect a cost difference, additional or a deduction in his bid proposal, then he shall so stipulate this sum and/or sums under the proper alternate(s) as provided for the bid proposals. Failure to do so will in no way relieve the hereinbefore stated contractors of their responsibilities regardless of what alternate(s) are selected at no extra cost will be charged to the Owner. Refer to Section 01 23 00, ALTERNATES for the list and description of Alternates.

D. Reference to Drawings: Work specified in Plumbing is subject to provisions of Section 44A to 44L inclusive, of Chapter 149 of General Laws of Massachusetts, as amended, and are indicated on all of the Contract Drawings. The Plumbing Work is shown on drawings P2.1, 2.2, P2.3, P2.4, P3.1, P3.2, P3.3, P3.4, P3.5, P3.6, P3.7, P3.8, P3.9, P3.10, P3.11, P3.12, P3.13, P3.14, P3.15, P3.16, P3.17, P3.18, P3.19, P3.20, P3.21, P4.1, P4.2, P4.3, P4.4, P4.5, P4.6, P4.7, P4.8, P4.9, P4.10, P4.11.

1. The Plumbing Subcontractor shall refer to all the Drawings enumerated in the List of Drawings on the title sheet for a full comprehension of the work to be done and for conditions affecting the location and placement of his equipment and materials. These Drawings are intended to be supplementary to the Specifications and any work indicated, mentioned, or implied in either is to be considered as specified by both. Should the character of the work herein contemplated or any matter pertaining thereto be not sufficiently explained in the Specifications or Drawings, the Plumbing Subcontractor may apply to the Architect-Engineer for further information and shall conform to such when given, as it may be consistent with the original intent. The Architect-Engineer reserves the right to make any reasonable changes in location prior to installation at no expense to the Owner. All lines are diagrammatic and exact locations are subject to the approval of the Architect-Engineer.

2. Before submitting his bid, the Plumbing Subcontractor shall visit the site with the Drawings and Specifications and shall become thoroughly familiar with all conditions affecting his work since the Plumbing Subcontractor will be held responsible for any assumption he may make in regard thereto.

3. The Plumbing Subcontractor shall, at all times, have a foreman or superintendent on the project authorized to make decisions and receive instructions as if the Plumbing Subcontractor himself were present. The foreman or superintendent shall not be removed or replaced without the express approval of the Architect-Engineer after construction work begins. The Plumbing Subcontractor shall employ only competent and experienced workmen at a regular schedule in harmony with the other tradesmen on the job. The Plumbing Subcontractor shall also exercise care and supervision of his employees in regards to proper and expeditious layout of his work.

E. EXAMINATION OF SITE AND DOCUMENTS

1. Bidders are expected to examine and to be thoroughly familiar with all contract documents and with the conditions under which work will be carried out. The Awarding Authority (Owner) will not be responsible for errors, omissions and/or charges for extra work arising from General Contractor or Filed Subcontractor's failure to familiarize themselves with the Contract Documents or existing conditions. By submitting a bid, the Bidder agrees and warrants that he has had the opportunity to examine the site and the Contract Documents, that he is familiar with the conditions and requirements of both and where they require, in any part of the work a given result to be produced, that the Contract Documents are adequate and that he will produce the required results.

2. Pre-Bid Conference: Bidders are strongly encouraged to attend the Pre-Bid conference; refer to INVITATION TO BID for time and date.

F. Related Work: The following items are not included in this Section and will be performed under the designated Sections:

1. SECTION EXECUTION.

   a. Cutting, patching, and drilling of holes larger than 4”, except installation of pipe supports and fastenings.
   b. All patching.

2. SECTION - EARTHWORK

   a. All excavation and backfill.

3. SECTION - WATER UTILITIES.

   a. Site distribution water piping, including stub-ups into building and hydrants.
   b. Site irrigation system after the connection from the plumbing system within the school
   c. Quick Connects and associated piping around field for cooling and washing down the synthetic turf after the connection from the plumbing system within the toilet/storage building.

4. SECTION - STORM DRAINAGE UTILITIES.

   a. Downspouts & gutters.

5. SECTION - CAST-IN-PLACE CONCRETE.

   a. All concrete work.
   b. Thrust blocks.

6. SECTION - ROOFING AND FLASHING.

   a. Vent flashings at the roof.

7. SECTION - PAINTING.

   a. All painting.

8. SECTION - EQUIPMENT.

9. SECTION 23 00 00 - HEATING, VENTILATING, AND AIR CONDITIONING.

    a. A/C condensate waste lines above finish floor slabs.
    b. Furnish Radon System Fans and controls.

10. SECTION 26 00 00 – ELECTRICAL (Also see specification section 2.43)

    a. Electrical connections and disconnect switches for boilers and all plumbing systems with power.
    b. Wiring of elevator sump pumps, circulating pumps and controls.
    c. Wiring of time clocks, solenoid valves, motors, controls and starters.
    d. Wiring of Laboratory Gas Control Panel in each Science Lab.
    e. Wiring of Radon Fan systems.
    f. Refer to paragraph 2.43 Electrical Work for systems that need to be wired but are included under the plumber's responsibility for hiring the Electrical Subcontractor.

G. The awarded Plumbing Contractor must have the required qualifications for the installation of specialty piping systems. These systems include laboratory waste and vent piping, pH neutralization system, radon systems, compressed air systems and all flue venting. If the plumber does not have these qualifications, then the work must be installed by a licensed and qualified plumber.

H. The Plumbing Subcontractor must comply with the requirements of the following sections:

1. SECTION 01 74 19 – CONSTRUCTION WASTE MANAGEMENT
2. SECTION 01 81 13– SUSTAINABLE DESIGN REQUIREMENTS
3. SECTION 01 81 19– INDOOR AIR QUALITY MANAGEMENT
4. SECTION 01 91 13 – COMMISSIONING REQUIREMENTS – BUILDING & ENVELOPE

It shall be the Plumbing Subcontractors responsibility to submit all documentation required of these sections pertaining to division 22 00 00 work. For Section 01 91 00 - Commissioning, division 22 00 00 must provide all personnel as required to fully coordinate with the commissioning agent. The hours of training and instruction outlined in division 22 00 00 requirements shall be in addition to those tests and requirements outlined in Commissioning section and required to the fulfill commissioning obligations.

I. Extent: The work required under this Section, without limiting the generality thereof, includes the furnishing of all labor, materials, equipment, and services necessary for, and reasonably incidental to, the complete installation of all piping, valves, boilers, storage tanks, pumps, fixtures, insulation of piping, gas and electric water heaters, grease and solids interceptors, acid neutralizing tank and monitoring equipment, oil interceptor and all other materials, equipment, and labor necessary, whether or not such items are specifically indicated on the Drawings or in the Specifications, to complete the plumbing system in all respects ready for continuous and trouble free operation.

J. Intent: It is the intent of the Contract Documents to include all work and materials necessary for erecting complete, ready for continuous use, all plumbing systems as shown on the accompanying Drawings or as hereinafter described. These Drawings shall be taken in a sense as diagrammatic; sizes of pipes and methods of running them are shown, but it is not intended to show every offset and fitting, nor every structural difficulty that will be encountered during the installation of the work.

1.3 CODES, STANDARDS AND REFERENCES

A. All materials and workmanship shall comply with the latest editions of all applicable Codes, Local and State Ordinances, Industry Standards and Regulations.

B. The Plumbing Subcontractor shall notify the Architect/Engineer of any discrepancies between the Contract Documents and applicable Codes, Standards, etc…

C. In the event of a conflict, the most stringent requirements shall apply.

D. The following Codes, Standards and References shall be utilized as applicable:

1. Massachusetts State Building Code, 9th Edition.
2. National Electric Code (NEC).
3. Environmental Protection Agency (EPA).
4. Commonwealth of Massachusetts Department of Environmental Protection (DEP).
5. Local Ordinances, Regulations of City of Worcester.
6. National Fire Protection Association (NFPA).
7. Insurance Services Organization (ISO).
8. American National Standards Institute (ANSI).
9. American Society of Mechanical Engineers (ASME).
10. American Society for Testing and Materials (ASTM).
11. American Welding Society (AWS).
12. Commercial Standards, U.S. Department of Commerce (CS).
13. National Electrical Manufacturers Association (NEMA).
14. American Gas Association (AGA).
15. Underwriters' Laboratories, Inc. (UL).
16. Massachusetts Uniform State Plumbing Code.
17. Massachusetts Architectural Access Board (MAAB).
18. American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE).
19. Manufacturers Standardization Society of the Valve and Fitting Industry (MSS).
20. Americans with Disabilities Act (ADA).
21. WaterSense Certification for Urinals and Urinal Flush Valves as well as Shower Valves and Shower Heads only.
22. NSF61G

Note: Special attention is called to the issue of compliance with NSF 61G (lead-free) requirements for all components of the plumbing system determined to be for 'drinking water' applications. In the context of these project, it shall be assumed that all Lavatory Faucets, regardless of method of operation (ie: manual, metering, electronic) shall be considered drinking water applications. Note that this also includes valves, thermometer wells and pressure gauge tees.

1.4 COORDINATION

A. Before starting work, visit site and examine conditions under which work shall be performed including preparatory work by others. Report conditions which might adversely affect the work in writing to the Architect. Do not proceed with the work until the defects have been corrected and conditions are satisfactory. Commencement of work shall be construed as acceptance of preparatory work and existing conditions.

B. Completely coordinate with work of other trades and provide for complete and fully functional installation. Although not specifically shown, provide supplementary or miscellaneous items, devices, appurtenances and materials incidental to or necessary for sound, secure and complete installation.

C. Coring, cutting and/or patching of all openings and holes 4” diameter and under required for the installation of the Plumbing in the building shall be performed by the Plumbing Subcontractor and all coring, cutting and/or patching of openings greater than 4” diameter shall be performed by the General Contractor in accordance with Section 01 73 29. The Plumbing Subcontractor shall be responsible for firestopping all penetrations in accordance with Section 07 84 00 Firestopping. All persons performing firestopping work must be trained and certified by the fire stopping manufacturer. Refer to section 2.11 for additional information.

D. All piping and equipment running within trusses must be supported from top chord of truss at panel point. For any alternate configurations or for heavy pieces of equipment coordinate fully with structural engineer for support location before installation.

1.5 GUARANTEE

A. Guarantee work performed under this Section in accordance with Division 1, General Requirements. Operation of systems or equipment for temporary services does not constitute beginning of guarantee period.

B. Starting dates for warranties prior to the Project Date of Substantial Completion are not permitted. Refer to Section 01 78 36 Warranties for exceptions. Please note that the main school building and the Outdoor Toilet and Storage Building are not built concurrently, so they will have different substantial completion dates. There shall be separate Letters of Warranty for these two buildings.

C. The Contractor also agrees to furnish service of the equipment for the above period, such service to be rendered quickly and promptly at the request of the Owner. This shall not be misconstrued to include routine maintenance.

D. For the domestic hot water boilers serving the school, provide extended 3-year warranty.

1.6 CONTRACT DOCUMENTS

A. Plumbing drawings do not limit responsibility of determining full extent of work required by Contract Documents. Locations shown on drawings shall be checked against construction proper.

1.7 DISCREPANCIES IN DOCUMENTS

A. Where Drawings or Specifications indicate discrepancies or are unclear, advise Architect in writing before award of Contract. Otherwise, Architect's interpretation of documents shall be final and no additional compensation shall be permitted due to discrepancies or unclear items.

B. Where Drawings or Specifications do not coincide with recommendations of the manufacturer of a material or piece of equipment, this shall be brought to the attention of the Architect in writing before installation of item in question. Otherwise, make changes in installation as Architect requires without additional cost to the Owner.

1.8 MECHANICAL AND ELECTRICAL COORDINATION DRAWINGS

A. Refer to Section 01 31 00 Progress Management and Coordination for coordination drawing requirements. Coordination drawings are required for this project.

1.9 RECORD DRAWINGS

A. Maintain record drawings during construction in accordance with the General Conditions of the Contract.

1.10 PERMITS, FEES, RULES AND REGULATIONS

A. Refer to Bidding and Contracting Requirements, including Document - GENERAL CONDITIONS and Documents - SUPPLEMENTARY CONDITIONS, for requirements all of which shall be included as part of this Specification.

B. Give the proper Authorities all requisite notices or information relating to the work under this Section. Obtain and pay for all fees, licenses, permits and certificates. Comply with the rules and regulations of all Local, State and Federal Authorities having jurisdiction, the Codes, Standards, recommended practices and manuals of the National Fire Protection Association, I.S.O., and the Public Utilities Companies serving the building.

C. All design data sheets and plans for the installation of backflow prevention devices shall be reviewed by a certified cross connection surveyor, in this case, the City of Worcester DPW Water Division.

1.11 NATURAL GAS SERVICE

A. This section shall expedite the Owner's application to Eversource Gas Company, supplier for the new gas service, meter and regulator for the building. The Plumbing Contractor shall pay the gas company charges, then be reimbursed by the owner for these costs. The work of this section shall begin at the outlet side of the gas meter. Regulator shall be set to provide sufficient gas pressure to the most pressure-demanding device. The contact at Eversource is Thomas O'Rourke. Note that this is a low pressure gas system.

1.12 SUBMITTALS

A. Refer to Section - SUBMITTALS for submittal provisions and procedures.

B. Submit shop drawings and product data through Submittal Exchange system (e-copies) or other Construction Management Software to Architect for approval (hard copies are not necessary unless requested). Any deviation from the Contract Documents, or proposed substitution of materials or equipment for those specified, must be requested by the Contractor in a separate letter, whether the deviations are due to field conditions, standard shop practices or other cause. Where any deviation or substitution is permitted, the Contractor shall fully coordinate all related changes to Architectural, Structural, Fire Protection, HVAC, Electrical or other work, and shall accomplish these related changes at no additional cost to the Owner. Refer to the general submittal requirements. Colors of all materials shall be as selected by the Architect-Engineer from the standard color ranges of each manufacturer from samples submitted as per below.

C. Submit shop drawing or product data for the following:

1. Plumbing fixtures, faucets, flush valves and accessories.
2. Piping, valves and accessories.
3. Floor drains, floor sinks, trench drains, roof drains and downspout outlets, wall hydrants (hose bibs), freeze proof sill cocks, roof hydrants and water hose reels.
4. Gas fired boilers and associated controls.

5. Domestic hot water storage tanks.
6. Mini-Tank point-of-use electric water heaters.
7. Outdoor Restroom and Storage Building tank-type electric water heater.
8. Thermal Expansion Tanks.
9. Circulating pumps and controls.
10. Pre-assembled high-low thermostatic water mixing valve or Digital mixing valve.
11. Emergency Shower & Eyewash/Facewash Thermostatic Mixing Valves (i.e. science room and individual at various locations throughout).
12. Pipe insulation.
13. Acid resistant piping.
14. Active pH neutralizing system with chemical feeds to adjust the pH of the effluent, p-trap with probe & pH monitoring panel with recording device.
15. Floor Access Panels/Hatches for Acid Neutralizing system components and for grease interceptor flow control fittings.
16. Radon system piping and installation of exhaust fans.
17. Pressure gauges and thermometers.
18. Expansion compensators (if not standard expansion loops).
19. Backflow preventers including domestic water service entrance x 2, science room cold and hot water piping x 2, kitchen appliances as required, site irrigation system, and boiler/chiller water feed.
20. Pressure reducing valves and pressure reducing control valve with by-pass.
21. Access Panels.
22. Time-clocks, solenoid valves, automatic trap primer valves with air gap fittings.
23. Trap guard inserts.
24. Pipe and equipment identification labels and valve tags.
25. Cleanouts.
26. Domestic hot water boiler flue and combustion air piping.
27. Interior Grease Interceptor.
28. Solids Interceptors.
29. Oil-Water Separator (interior to building by plumber).
30. Oil Interceptor for Outdoor Restroom and Storage Building.
31. Piping hangers and seismic bracing.
32. Compound water meter for main school, water meter for site irrigation system, and water meter for outdoor restroom and storage building.
33. Triplex, variable speed, domestic water pressure booster system and all associated components.
34. Gas Pressure Regulators.
35. Air compressor system related accessories including refrigerated air dryer, air filters, piping, valve, quick connect fittings and air hose reels. Air compressors and receivers by FF&E.
36. Science room fixtures including faucets, gas/air turrets, piping for sinks and piping for all equipment including ice makers, glass washers, refrigerators, fume hoods, etc…
37. Science room emergency gas shut-off and non-emergency gas valve box.
38. Automatic Elevator Sump Pumps with Sump Tanks and Covers and High Level Alarm.
39. Water Sub-Meters with pulse output to BMS.
40. Gas Sub-Meters with pulse output to BMS.
41. Temperature Maintenance Electric Heat Trace systems.
42. Freeze Protection Electric Heat Trace systems.
43. Grease Line Maintenance Electric Heat Trace system.
44. BIM Coordination drawings.

Do not release for shipment, deliver, or install any equipment or material without prior approval of the Architect-Engineer.

1.13 DELIVERY, STORAGE, AND HANDLING

A. Delivery: The Plumbing Subcontractor shall provide for the delivery of all his materials and fixtures to the building site when required so as to carry on his work efficiently and to avoid delaying his work and that of other trades.

B. Storage and Handling: The Plumbing Subcontractor shall, at all times, fully protect his work and materials from injury or loss by others. Any injury or loss, which may occur, shall be made good without expense to the Owner. The Plumbing Subcontractor shall be responsible for the proper protection of all his materials until the building is accepted by the Owner.

1.14 CONTINUITY OF SERVICE AND SCHEDULING OF WORK

A. Refer to the overall scheduling of the work of the project. Schedule work to conform to this schedule and install work to not delay nor interfere with the progress of the project.

1.15 CERTIFICATES OF APPROVAL

A. Upon completion of all work, furnish, in duplicate, certificates of inspection.

1.16 OPERATING AND MAINTENANCE INSTRUCTIONS

A. Prior to the final inspection, the Plumbing Subcontractor shall provide to the Architect electronic versions of operating and maintenance instructions. The Architect-Engineer shall review the instructions for completeness prior to turning them over to the Owner. Refer to SECTION 01 78 00 CLOSEOUT SUBMITTALS for additional information and requirements.

B. Instructions: The Plumbing Subcontractor shall provide qualified, factory-trained manufacturers' representative to give detailed instruction to assigned Owner personnel in the operation and complete maintenance for all equipment. All such training will be at the job site. Training must be provided on the operation of major equipment and fixture maintenance. The pH neutralizing system care & maintenance shall be addressed as well as the various mixing valves throughout the building. The science room Natural Gas Service Panels need to be tested to ensure proper operation. General fixture maintenance for the flush valves, faucets, shower valves, water coolers, etc. should be included. Coordinate training requirements with MSBA training requirement is Section 01 79 00.

1. Science Room Gas Shut-Off Valves and remote gas-shut-off buttons must be tested for every science lab/classroom to ensure the gas is properly shut-off to the room.
2. pH Neutralizing System must be installed, tested and operating for the opening of school. Plumber shall ensure that the necessary manufacturers representatives are contacted to make this happen.

C. Factory Start-Up: The Plumbing Subcontractor shall provide factory start-up of the gas-fired domestic hot water boilers, triplex pressure booster pump system and pH neutralizing system. A factory start-up checklist shall be submitted for approval with the close-out documents. Note: The small electric water heaters do not require factory start-up.

D. Provide name, address, and telephone number of the manufacturer’s representative and service company for each piece of equipment so that the source of replacement parts and service for each item of equipment can be readily obtainable.

1.17 SEISMIC RESTRAINTS

A. Installation of Plumbing equipment, accessories and components shall be in accordance with the Seismic Requirements identified in the 9th Edition of the Massachusetts State Building Code. Note that the code exception based on the following may not apply to meet Emergency Shelter requirements:
Mass State Building Code → IBC 2009 → Section 16.13.1 → ASCE 13.1.4 (2)

B. Provide seismic bracing as required by the Commonwealth of Massachusetts building code 780 CMR, 9th edition, Chapter 16. Plumbing Subcontractor shall hire a seismic consultant to comply with requirements of the code. All equipment and piping shall be seismically supported regardless of it is exempt by 780 CMR Chapter 16. For the purposes of seismic design, the entire Plumbing system shall be presumed to have a seismic importance factor of 1.25. Plumbing Contractor must provide vibration isolation and cables for seismic restraint regardless of the code exception.

1.18 ENVIRONMENTAL REQUIREMENTS

A. Recycled Content: Provide products manufactured from recycled content, to be measured and documented according to LEED.

B. Low Volatile Organic Compounds (VOCs): Adhesives used on site must meet the VOC limits of the California South Coast Air Quality Management District Rule #1168. Sealants used as filler must meet or exceed Bay Area Air Quality Management District Regulation 8, Rule 51.

1.19 LEED v4 GENERAL REQIUREMENTS

A. The work of this Section is required to comply with general requirements and procedures for compliance with prerequisites and certain credits required for the Project to obtain Certified rating based on USGBC's LEED v4 Reference Guide for Building Design and Construction and as outlined in Division 01 Section “Sustainable Design Requirements.”

1. The Construction Manager is responsible to coordinate with the work of other Sections and comply with all LEED v4 requirements in accordance with the Contract Documents such that the work carried out by this Section does not compromise the achievement of any other LEED v4 prerequisites and credits applicable to the entire Project.

B. Related Sections for Sustainable Design Requirements:

1. Section 01 25 13 “Product Substitution Procedures” for product substitutions.
2. Section 01 33 00 “Submittal Procedures” for LEED v4 submittal requirements.
3. Section 01 50 00 “Temporary Facilities and Controls” for requirements for temporary facilities.
4. Section 01 60 00 “Product Requirements” for additional LEED v4 submittal requirements.
5. Section 01 74 19 “Construction Waste Management” for waste management, recycling and disposal.
6. Section 01 81 13 “Sustainable Design Requirements” for general procedures for compliance with LEED v4 prerequisites and credits.
7. Section 01 81 19 “Indoor Air Quality Requirements” for material and procedure requirements.

1.20 SEQUENCING

A. Phasing: Refer to Section 01 10 00 - SUMMARY, and Drawings for phasing and milestone completion requirements which affect the Construction Manager's Work and the Work of this Trade Contractor.

B. Coordinate work of this Trade Contract with that of other trades, affecting or affected by this work, and cooperate with the other trades as is necessary to assure the steady progress of work.

C. Do not order or deliver any materials until all submittals, required in the listed Specification Sections included as part of this Trade Contract, have been received and approved by the Architect.

D. Before proceeding with installation work, inspect all project conditions and all work of other trades to assure that all such conditions and work are suitable to satisfactorily receive the work of this Section and notify the Architect in writing of any which are not. Do not proceed further until corrective work has been completed or waived.

E. Refer to the Construction Managers Supplemental Instructions to bidders, section 00 73 00, Project Phasing Requirements Section 01 12 00, for summary of partial work that has been completed, and this contractors coordination and work responsibilities for the remaining scope, briefly summarized as follows.

1. Some foundation sleeves and penetrations have been installed. All other foundation penetrations are to be core drilled under this work scope
2. Coordination drawings have progressed setting some roof drain locations and some drain line locations.

PART 2 - PRODUCTS

2.1 PRODUCTS CRITERIA

A. Standard Products: Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products for at least 3 years. See other specification sections for any exceptions.

B. Multiple Units: When two or more units of materials or equipment of the same type or class are required, these units shall be products of one manufacturer.

C. Nameplates: Nameplate bearing manufacturer's name or identifiable trademark shall be securely affixed in a conspicuous place on equipment, or name or trademark cast integrally with equipment, stamped or otherwise permanently marked on each item of equipment.

D. Asbestos products or equipment or materials containing asbestos shall not be used.

E. Lead free products shall be used for all piping, fittings, valves, faucets and any other component that comes in contact with potable water.

F. Plumbing equipment, fixtures and valves shall each have a Massachusetts Plumbing Board product approval number which can be found on the Acceptable Plumbing Products website. The Plumbing Contractor will be expected to produce the approval numbers for any and all

equipment, fixtures and valves during the submittal process and at installation for anyone who asks (i.e. the Plumbing Inspector, Plumbing Engineer, etc…). Products without a Massachusetts Plumbing Product Approval code will be rejected and will not be allowed on the job-site. Plumbing product approval numbers shall be included in the close-out documents. Piping is not required to be MA Plumbing product approved since it is not included on the website.

2.2 PLUMBING FIXTURES - SCHOOL

A. Provide plumbing fixtures as specified herein. Fixture trim, traps, faucet, escutcheons and waste pipes exposed to view in finished spaces shall be I.P.S. brass with polished chromium plating over nickel finish. Fixtures shall have manufacturer's label or trademark indication first quality.

B. Fixtures with wall outlet flanges shall be set proper distance from floor or wall to make first-class joint with closet setting compound or gasket.

C. Mounting heights shall be as shown on architectural details.

D. Each individual fixture shall be provided with supply stops for each water service. Supply stops and supply risers shall be lead-free to meet NSF-61G.

E. Exposed piping below handicap lavatories and sinks shall be insulated with PVC coated insulation similar to Truebro LavGuard 2, McGuire Mfg. Co. Inc., Plumberex Specialty Products Pro-Extreme, ProFlo Trap Covers for Ferguson Enterprises or approved equal. The product shall be rigid high-impact, stain-resistant PVC, 1/8” constant wall thickness with internal ribs, have UV protection, and have an E-Z Tear-To-Fit trim feature. The color shall be china white and shall be Compatibility #100 series to fit all 1-1/4” or 1-1/2” cast brass or tubular P-trap assemblies and 3/8” or ½” angle stop assemblies.

F. Fixture stops shall be similar to McGuire ICV Defender series with loose key control or approved equal. These are manufactured to a heavy pattern angle stop specification and are available in IPS, sweat or compression connections. They shall have an integral check valve, be spring actuated and be completely serviceable. They are engineered to address cross-connection contamination. These valves shall have a 3-year warranty.

G. Manual Flush Valves are specified as Diaphragm Type. Piston Type flush valves are considered a substitution and will need to be reviewed by the project team and owner to determine if they are acceptable. If Piston Type Flush Valves are rejected, the Plumbing Contractor will submit Diaphragm Type for approval.

H. Fixture Schedule: Unless otherwise specified, fixtures shall be as follows (Note: Manufacturer and Model numbers are provided to set standard of fixture) :

1. China Fixtures including Water Closets, Urinals and Lavatories: American-Standard, Kohler Company, Zurn ZPPG, Eljer Plumbingware Inc., Crane Plumbing, Sloan Valve Company or equal.
2. Manual Flush Valves – Diaphragm Type: Sloan Valve Company, Zurn ZPPG, Delta Faucet Company, Moen Commercial or equal.
3. Manual Lavatory Faucets: Symmons Industries Inc., Delta Faucet Company, Moen Commercial, American Standard, Zurn ZPPG, Chicago Faucets or equal.
4. Multi-Station Washfountains with integral faucet spouts: Bradley Corporation, Sloan Valve Company, Willoughby Industries Inc., Intersan or equal.

5. Countertop Sinks: Elkay Sales Inc., Just Manufacturing Co., Kohler Company, Kindred Commercial or equal.
6. Countertop Sink Faucets: Symmons Industries Inc., American Standard, Zurn ZPPG, Chicago Faucets, Moen Incorporated, Delta Commercial or equal.
7. Water Coolers with and without Bottle Fillers: Elkay Sales Inc., Halsey Taylor, Oasis Corporation, Haws Corporation, Filtrine, Murdock or equal.
8. Mop Receptor: Crane Plumbing/Fiat Products, Stern-Williams Co. Inc., Zurn ZPPG, E.L. Mustee & Sons, Florestone Products Co. or equal.
9. Mop Receptor Faucets: Moen Commercial, Crane Plumbing/Fiat Products, Stern-Williams, American Standard, Chicago Faucets, Speakman Co. or equal.
10. Shower Stall: none required. There are no pre-fabricated shower stalls.
11. Shower Bases: Fiat Products, Swan, Florestone, or equal.
12. Shower Valves: Bradley Corporation, Symmons Industries Inc., Zurn ZPPG, Powers (a Watts Industries Co.), Leonard Valve Co., Delta Commercial or equal.
13. Clothes Washer Connections: Symmons Industries Inc., Sioux Chief, Oatey or equal.
14. Emergency Fixtures: Chicago Faucets, Guardian Equipment, Bradley Corporation, Speakman Company, Haws, Acorn Engineering Company, or equal.
15. Bariatric Fixtures: Acorn Engineering Company, Whitehall Manufacturing, Willoughby Industries, or equal.

P1 Wall Hung Water Closet – Non-Handicap: American Standard #2257.101 “Afwall Millennium FloWise” (Kohler model #K-4325 “Kingston”), High Efficiency 1.28 gpf (HET), vitreous china, wall hung, conventional glaze, condensation channel, concealed trapway design, direct-fed siphon jet, elongated bowl, 1-1/2” top spud inlet, 2-1/8” ballpass fully glazed trapway, 10”x12” water surface area, static weigh load = 1000 LBS, 100% factory flush tested.
Sloan Royal model #111-1.28; exposed water closet flushometer for floor mounted or wall hung top spud bowls. Flushometer shall be quiet, exposed, diaphragm type, chrome plated for left or right hand supply, water closet type with the following features:

- PERMEX™ synthetic rubber diaphragm with dual filtered fixed bypass.
- ADA compliant metal oscillating non-hold-open handle with triple seal handle packing.
- 1” I.P.S. screwdriver Bak-Chek® angle stop with free spinning vandal resistant stop cap.
- Adjustable tailpiece.
- High back pressure vacuum breaker flush connection with one-piece bottom hex coupling nut
- Spud coupling and flange for 1-1/2” top spud.
- Sweat solder adapter with cover tube and cast wall flange with set screw.
- High copper, low zinc brass castings for dezincification resistance.
- Non-Hold-Open handle, fixed metering bypass and no external volume adjustment to ensure water conservation.
- Flush accuracy monitored by CID™ Technology.
- Diaphragm, stop seat and vacuum breaker molded from PERMEX™ rubber compound for chloramines resistance.

Bemis #495SSC extra heavy weight, thermoset fireproof material, elongated, open front seat, less cover with integral molded-in bumpers, self-sustaining and external check hinge feature 300 series stainless steel posts that hold seat in any raised position up to 11 degrees beyond vertical, color white. Church #9500SSCT, Kohler #K-4731, or approved equal.
Zurn Industries, Jay R. Smith, Josam or equal hub and spigot combined waste fitting and chair carrier supports, with adjustable extensions, rear foot support and face plate with foot support & feet bolted to floor, with seat mounting height to be 15” above finished floor.

P2 Wall Hung Water Closet – Handicap: Same as P-1 except mounted 18" floor to rim. Modify flush valve to allow clearance for grab bar installation. Note that the flush valve handle shall be on the wide side or the water closet and not the narrow side per 521 CMR.

P3 Wall Hung Urinal – Non-Handicap: American Standard #6590.001 "Washbrook FloWise 0.125 GPF Ultra High Efficient Urinal (Kohler model #K-4904-ET "Bardon"), vitreous china, low consumption 0.125 GPF, flushing rim, elongated 14" rim from finished wall, washout flush action, extended sides for privacy, ¾" inlet spud, outlet connection threaded 2" inside (NPTF), chrome plated non-metallic strainer included, meets ANSI flush requirements for 0.125 GPF.
Sloan Royal model #186-0.125; exposed high efficiency manual urinal flushometer for top spud high efficiency urinals. Flushometer shall be quiet, exposed, diaphragm type, chrome plated, urinal type with the following features:

- Dual linear filtered bypass diaphragm.
- ADA Compliant metal oscillating Non-Hold-Open handle with triple seal handle packing
- 3/4" I.P.S. screwdriver Bak-Chek® angle stop with free spinning vandal resistant stop cap.
- Adjustable tailpiece.
- High back pressure vacuum breaker flush connection with one-piece bottom hex coupling nut
- Spud coupling and flange for 3/4" top spud.
- Sweat solder adapter with cover tube and cast wall flange with set screw.
- High copper, low zinc brass castings for dezincification resistance.
- Non-Hold-Open handle, fixed metering bypass and no external volume adjustment to ensure water conservation.
- Flush accuracy monitored by CID™ Technology.
- Diaphragm, handle packing, stop seat and vacuum breaker molded from PERMEX™ rubber compound for chloramines resistance.

Provide Zurn #Z1222 concealed carrier, Jay R. Smith, Josam or equal carrier, with bearing and hanger plates (vandalproof trim) or provide carrier as required to suit construction, with feet bolted to floor. Install with rim at 24" above finished floor.

P4 Wall Hung Urinal - Handicap: Same as P-5 except mounted 17" floor to rim.

P5 Wall Hung Lavatory – Non-Handicap: American-Standard #0954.004 "Murro" wall-hung bathroom sink (Kohler model #K-1997 "Brenham"), 22" deep x21-1/4" wide, vitreous china, wall hung, rear overflow, 4" faucet hole centers, recessed self-draining deck, for concealed arm support.
Chicago Faucets model #3600-E39VPAB deck mounted hot and cold water manual metering mixing sink faucet, 4" fixed centers, chrome plated, integral cast brass spout with 5-5/8" center to center, 0.35 GPM vandal proof pressure compensating Econo-Flo non-aerating spray, #MVP self-closing auto timed metering with adjustable run time from 2 – 25 seconds which opens with push, 0.2 maximum gallons / cycle, stainless steel braided supply hoses included, with 3/8" compression thread. This product meets ADA ANSI/ICC A117.1 requirements and is tested and certified to industry standards: ASME A112.18.1, Certified to NSF/ANSI 61.
Chicago #STC-11-11-AB Heavy Duty lead-free, loose key stops and supplies with flexible riser and flange. 1-1/4" x 1-1/2" polished chrome plated cast brass adjustable "P" trap, cleanout plug, extension to wall with escutcheon.
Concealed arm carrier support with foot support to suit construction. Install with rim at 36" maximum above finished floor.

P6 Wall Hung Lavatory –Handicap: American-Standard #0954.004 “Murro” wall-hung bathroom sink (Kohler model #K-1997 “Brenham”), 22” deep x21-1/4” wide, vitreous china, wall hung, rear overflow, 4” faucet hole centers, recessed self-draining deck, for concealed arm support.
Chicago Faucets model #3600-E39VPAB deck mounted hot and cold water manual metering mixing sink faucet, 4” fixed centers, chrome plated, integral cast brass spout with 5-5/8” center to center, 0.35 GPM vandal proof pressure compensating Econo-Flo non-aerating spray, #MVP self-closing auto timed metering with adjustable run time from 2 – 25 seconds which opens with push, 0.2 maximum gallons / cycle, stainless steel braided supply hoses included, with 3/8” compression thread. This product meets ADA ANSI/ICC A117.1 requirements and is tested and certified to industry standards: ASME A112.18.1, Certified to NSF/ANSI 61.
Chicago #STC-11-11-AB Heavy Duty lead-free, loose key stops and supplies with flexible riser and flange. 1-1/4” x 1-1/2” polished chrome plated cast brass adjustable “P” trap, cleanout plug, extension to wall with escutcheon.
Concealed arm carrier support with foot support to suit construction. Install with rim at 34” maximum above finished floor.
Insulate cold water, hot water, and waste beneath lavatory. Refer to paragraph 2.2.E for additional information.

P7 Bi-Level Water Cooler with Bottle Filler and Filter - Handicap: Halsey Taylor model #HTHBWF-OVLSER-I complete bi-level barrier free water cooler with HydroBoost® bottle filling station; shall deliver 8.0 GPH of 50ºF water at 90ºF ambient and 80ºF water inlet. Unit shall include bi-level oval fountains with integral bottle filling station constructed of stainless steel and ABS plastic. Bottle filler shall include electronic sensor for no-touch activation with automatic 20-second shut-off timer. It shall provide 1.5 GPM flow rate with laminar flow to minimize splashing. It shall include anti-microbial protected plastic components to prevent mold and mildew. Fountains shall include front pushbar activation and shall have oval contour-formed basins to eliminate splashing and standing water, and rounded corners and edges. Bubblers shall be chrome plated, two-stream, mount-building type with integral good guard and anti-squirt feature. Unit shall include WaterSentry Plus filter, certified to NSF/ANSI 41 & 53 for lead reduction, with visual monitor to indicate when replacement is necessary. Cooling unit shall have a high efficiency positive start compressor using R134A, with pressurized counterflow cooling evaporator/chiller. The water cooler shall have a 1/5 HP compressor rated for 370 Watts at 115V-1Ø power, 4.0 full load amps. A wall mounting frame is furnished with the water cooler for easy installation. The manufacturer shall certify the unit to meet the requirements of ANSI/NSF 61, Section 9 and the Safe Drinking Water Act. Unit complies with ARI Standard 1010.
Provide angle stop and “P” trap with cleanout for the fountain.
Separate power may be required for the bottle filler. It is the responsibility of the Plumber to make sure this is coordinated and that a junction box and outlet is provided for this if required.

P7A Bi-Level Water Cooler - Handicap: Halsey Taylor model #OVLSERGRN-VRWF complete bi-level barrier free water cooler; shall deliver 8.0 GPH of 50ºF water at 90ºF ambient and 80ºF water inlet. Unit shall include bi-level oval fountains constructed of stainless steel and ABS plastic. Fountains shall include mechanical front bubbler button activation and shall have oval contour-formed basins to eliminate splashing and standing water, and rounded corners and edges. Bubblers shall be chrome plated, two-stream, mount-building type with integral good guard and are vandal resistant. Unit shall include Water filter is certified to NSF/ANSI 42 & 53 for lead reduction, particulate, chlorine, taste and odor reduction, 1500 gallon capacity. Cooling unit shall have a high efficiency positive start compressor using R134A, with pressurized counterflow cooling evaporator/chiller. The water cooler shall include an Energy Savings feature which allows for the refrigeration to be

powered off when not in use. The water cooler shall have a 1/5 HP compressor rated for 370 Watts at 115V-1Ø power, 4.0 full load amps. A wall mounting frame is furnished with the water cooler for easy installation. The manufacturer shall certify the unit to meet the requirements of ANSI/NSF 61, Section 9 and the Safe Drinking Water Act. Unit complies with ARI Standard 1010. Unit shall be GreenSpec Listed.
Provide angle stop and "P" trap with cleanout for the fountain.

P8 Utility Sink/Laundry Tub: Fiat model #FL-1 Floor Mounted Serv-A-Sink®, single molded-stone floor mounted laundry tub complete with white baked enamel legs and leveling feet, 23"x22" nominal size, 20 gallon capacity, 33-1/2" floor to rim.
Chicago Faucets model #1891-ABCP Deck Mounted 4" Fixed Centers Hot and Cold Water Sink Faucet, 4" fixed centers, 6" S type swing spout, 2.2 GPM aerator, 2" vandal proof canopy single wing handle, Quaturn compression operating cartridge, ½" NPSM supply inlets and coupling nut for 3/8" or ½" flexible riser, ECAST® design. Lifetime limited faucet warranty. 5-Year limited cartridge warranty. 1-Year limited finish warranty.
Fiat model #A-2 Overflow Pipe.

P9 Wall Hung Sink for Ensemble Rooms: Elkay model #WCL1923OSDC "Sturdibilt" Stainless Steel 19"x23"x4" Wall Hung Single Bowl Lavatory Sink Kit; sink is manufactured from 18 gauge, 304 stainless steel with lustrous satin finish, rear center drain placement and bottom pads only, 3 faucet holes on 8" centers. The kit includes the Elkay sink, faucet and drain. The sink is ADA compliant.
Elkay model LKD232SBH5C 8" Centerset Concealed Deck Mount Faucet with Gooseneck Spout and 4" Lever Handles and Stop Chrome. The faucet has a flow rate of 1.5 GPM and is made of chrome plated brass material with a quarter turn ceramic disc valve. Faucet requires 3 faucet holes. Handles are 4" lever style.
Elkay model #LKAD174LO drain. 1-1/2" or 1-5/8" drain outlet fitting chrome plated brass, perforated grid and elbow with overall dimensions of 6-7/8" x 2-1/4" x 11-7/16", made of brass. This is not arranged for an overflow drain.
Insulate cold water, hot water, and waste beneath sink. Refer to paragraph 2.2.E for additional information.

P10 Recessed Wall Mounted Combination Emergency Shower and Eye/Face Wash:
Guardian model #GBF2150 Recessed Laboratory Unit with the following features:

1. SSBF-44* – Barrier Free, recessed, wall mounted combination eye/face wash and shower safety station with ceiling mounted exposed shower head, patented stainless steel shower-actuating arm and swing-down stainless steel combination eye/face wash drain pan. Unit construction shall be welded 16-gauge type 304 stainless steel with #4 brushed satin finish. Unit shall include stainless steel shower head, internal 20 GPM flow control, supply nipple, escutcheon, chrome-plated brass eye/face wash supply fittings, brass unions, and U.S made full-port brass ball valve for shower. Eye/face wash valve shall be AutoFlow™, plug-type design with PTFE coated O-rings to seal valve orifices, polypropylene FS-Plus™ spray heads with individual 3.2 GPM flow controls and polyurethane filters. Supplied with in-line strainer to protect eye/face wash valve and spray heads from debris in water line, and 2" IPS drain. Activate eye/face wash valve by rotating 90° from stored position. Unit shall include ANSI compliant sign.
2. Performance: Unit complies with ADA requirements for accessibility by handicapped persons. Unit shall be fully factory assembled and hydrostatically tested to meet or exceed ANSI Z358.1 – 2014, and come with a full 2-year warranty.

P11 Floor Mounted Mop Receptor: Fiat model #MSBID-3624 molded stone mop service basin, 36"x24"x10"D, 1" wide shoulders; factory installed drain body shall be stainless steel and designed to provide for a lead caulk or QDC-3 joint to a 3" drain pipe.

Chicago model #445-897S-XKRCCP service sink faucet with integral check and stops, cast brass spout with VB and pail hook, 8" centers.
Fiat Mop Hanger #889-CC; 24" long by 3" wide, stainless steel attached with three (3) rubber tool grips.
Fiat Hose and Hose Bracket #832-AA; 30" long flexible, heavy duty, 5/8" rubber hose, cloth reinforced, with ¾" brass coupling at one end. Bracket is 5" long by 3" wide. 18 gauge #302 stainless steel with rubber grip.

P12 Shower Base and Valve – Non-Handicap: Tile shower stall by G.C.
Florestone Terrazzo Model #200 Recess Shower Receptor, 36"x36". Shoulder will be not less than 2-1/2" inside. Flange, cast integral, will be galvanized-bonderized steel and extend not less than 1" above shoulder on three (3) sides for installation. Drain body will be brass, cast integral, and will provide for a non-caulked connection not less than 1" deep to a 2" pipe. Receptor will be manufacturer of tan and white marble chips cast in white Portland cement to produce a compressive strength of not less than 3,000 PSI, 7 days after casting. Terrazzo surface will be ground, polished, and the entire unit sealed to resist stains and moisture after any air holes and/or pits are grouted. Receptor will be reinforced with 16 gauge wire. Removeable type stainless steel strainer plate will be supplied.
Moen Commercial model #8375EP15 Single Handle Pressure Balancing Shower Valve with Integral Stops; chrome plated metal construction, pressure balancing cycle valve design, ½" CC connections with ¼ turn stops (included), vandal resistant screws. Operation shall be lever style handle with temperature indicators on the escutcheon, handle operates counterclockwise through a 270° arc with off at 6 o'clock and maximum hot at the 9 o'clock position. Shut-off in a clockwise direction. Adjustable temperature limit stop to restrict the handle travel in the hot direction. Moen #1222 cartridge design with nonmetallic/nonferrous and stainless steel materials.
Moen Commercial model #8290 Vandal Proof Showerhead; fixed mount vandal proof showerhead, metallic spray face and shell, brass swivel ball assembly, adjustable spray angle, designed to deliver 1.5 GPM at 60 PSI.
Provide floor drain in center of shower stall.

P13 Shower Valve - Handicap: Tile shower stall and base by G.C.
Moen Commercial model #8346EP15 Single-Handle Pressure Balancing Shower Valve with Hand-Held Shower System; chrome plated metal construction, pressure balancing cycle valve design with ¼ turn stops. System contains hand-held shower with 36" slide bar, drop ell, vacuum breaker, 69" metal hose and hardware. Operation shall be lever style handle with temperature indicators on the escutcheon, handle operates counterclockwise through a 270° arc with off at 6 o'clock and maximum hot at the 9 o'clock position. Shut-off in a clockwise direction. Adjustable temperature limit stop to restrict the handle travel in the hot direction. Moen #1222 cartridge design with nonmetallic/nonferrous and stainless steel materials. 1.5 GPM Hand-Held Shower Head.
Provide collapsible water dam with endcaps along front edge of shower stall similar to K.R. Specialties, Stay Dry Systems or Freedom Showers Collapsible Water Retainers.
Provide floor drain in center of shower stall, unless noted otherwise.

P14 Countertop Sink – Planning Rooms - Handicap: Elkay model #LRADQ1919-65-3 "Lustertone" 19-1/2"x19" nominal, single 16"x13-1/2" bowl, 18-gauge type 304 stainless steel, self-rimming countertop sink; highest quality; seamlessly drawn from nickel bearing stainless steel; bowl depth = 6-1/2"; 1-3/4" radius coved corners; exposed surfaces hand blended to a lustrous highlighted satin finish; bowl and faucet deck are recessed 3/16" below outside edge of sink; underside fully protected by a heavy duty Sound Guard undercoating; 3-1/2" drain opening; faucet holes on 8" centers; 3 faucet holes; Quick-Clip.
Chicago Faucets model #201-A3I7ABCP deck mounted 8" fixed centers concealed hot and cold water sink faucet, 9-1/2" L type swing spout, 2.2 GPM aerator, 4" vandal proof wrist-

blade handles, Quaturn compression operating cartridge, ½" NPSM supply inlets and coupling nut for 3/8" or ½" flexible riser, ECAST design for reduced lead content.
Elkay model #LK35 Standard Cup Strainer, fits 3-1/2" opening (4-1/2" top diameter), stainless steel conical strainer basket with flex stem and rubber stopper, C.P. brass, 1-1/2" O.D. tailpiece.
Chicago #STC-11-11-AB Heavy Duty lead-free, loose key stops and supplies with flexible riser and flange. 1-1/2" x 1-1/2" polished chrome plated cast brass adjustable "P" trap, cleanout plug, extension to wall with escutcheon.

P15 Art Classroom Sink –Handicap: Elkay model #ELUHAD1414-55 "Lustertone" Classic Stainless Steel 16-1/2"x16-1/2"x5-3/8" deep single bowl undermount ADA sink, single 14"x14" bowl, 18-gauge type 304 stainless steel, under- counter mounted sink; highest quality; seamlessly drawn from nickel bearing stainless steel; bowl depth = 5-3/8"; 1-3/4" radius coved corners; exposed surfaces hand blended to a lustrous highlighted satin finish; underside fully protected by a heavy duty Sound Guard undercoating; 3-1/2" rear center drain opening.
Chicago Faucets model #201-AGN2AE3ABCP sink faucet for hot and cold water, concealed deck mount with 8" fixed centers, chrome plated; rigid/swing gooseneck spout, 5-1/4" center-to-center; 2.2 GPM pressure compensating Softflo aerator; 2-3/8" metal, vandal-proof, lever handles with sixteen point, tapered broach and secured blue and red index buttons; Quaturn™ rebuildable compression cartridge, opens and closes 90°, closes with water pressure, features square, tapered stem; ½" NPSM supply inlets and coupling nut for 3/8" or ½" flexible riser; ECAST® construction with less than 0.25% lead content by weighted average; ADA compliant, Certified to NSF/ANSI 61.
Elkay model #LK35 Standard Cup Strainer, fits 3-1/2" opening (4-1/2" top diameter), stainless steel conical strainer basket with flex stem and rubber stopper, C.P. brass, 1-1/2" O.D. tailpiece.
Chicago #STC-11-11-AB Heavy Duty lead-free, loose key stops and supplies with flexible riser and flange.
Zurn #Z-1180, Josam series 61030 or equal fixture trap type solids interceptor in lieu of trap, top access, gasketed cover, removable galvanized steel basket and stainless steel screen. See specification section 2.16 for additional information. Coordinate with casework manufacturer and Architect for installation.

P16 Art Classroom Sink – Non-Handicap: Elkay model #ELU281610 "Lustertone" Undermount Sink 30-1/2"x18-1/2" overall, single 28"x16" bowl, 18-gauge type 304 stainless steel, under- counter mounted sink; highest quality; seamlessly drawn from nickel bearing stainless steel; bowl depth = 10"; 1-3/4" radius coved corners; exposed surfaces hand blended to a lustrous highlighted satin finish; underside fully protected by a heavy duty Sound Guard undercoating; 3-1/2" drain opening; template and countertop mounting clips are included.
Chicago Faucets model #201-AGN8AE3-317VAB sink faucet for hot and cold water, concealed deck mount with 8" fixed centers, chrome plated; rigid/swing gooseneck spout, 8" center-to-center; 2.2 GPM pressure compensating Softflo aerator; 4" metal, vandal-proof, wristblade handles with sixteen point, tapered broach and secured blue and red index buttons; Quaturn™ rebuildable compression cartridge, opens and closes 90°, closes with water pressure, features square, tapered stem; ½" NPSM supply inlets and coupling nut for 3/8" or ½" flexible riser; ECAST® construction with less than 0.25% lead content by weighted average; ADA compliant, Certified to NSF/ANSI 61.
Elkay model #LK35 Standard Cup Strainer, fits 3-1/2" opening (4-1/2" top diameter), stainless steel conical strainer basket with flex stem and rubber stopper, C.P. brass, 1-1/2" O.D. tailpiece.
Chicago #STC-11-11-AB Heavy Duty lead-free, loose key stops and supplies with flexible riser and flange.

Zurn #Z-1180, Josam series 61030 or equal fixture trap type solids interceptor in lieu of trap, top access, gasketed cover, removable galvanized steel basket and stainless steel screen. See specification section 2.16 for additional information. Coordinate with casework manufacturer and Architect for installation.

P16A Art Classroom Sink – Handicap: Elkay model #ELUH281655 “Lustertone” Undermount Sink 30-1/2”x18-1/2” overall, single 28”x16” bowl, 18-gauge type 304 stainless steel, under- counter mounted sink; highest quality; seamlessly drawn from nickel bearing stainless steel; bowl depth = 5-3/8”; 1-3/4” radius coved corners; exposed surfaces hand blended to a lustrous highlighted satin finish; underside fully protected by a heavy duty Sound Guard undercoating; 3-1/2” drain opening; template and countertop mounting clips are included.
Chicago Faucets model #201-AGN8AE3-317VAB sink faucet for hot and cold water, concealed deck mount with 8” fixed centers, chrome plated; rigid/swing gooseneck spout, 8” center-to-center; 2.2 GPM pressure compensating Softflo aerator; 4” metal, vandal-proof, wristblade handles with sixteen point, tapered broach and secured blue and red index buttons; Quaturn™ rebuildable compression cartridge, opens and closes 90°, closes with water pressure, features square, tapered stem; ½” NPSM supply inlets and coupling nut for 3/8” or ½” flexible riser; ECAST® construction with less than 0.25% lead content by weighted average; ADA compliant, Certified to NSF/ANSI 61.
Elkay model #LK35 Standard Cup Strainer, fits 3-1/2” opening (4-1/2” top diameter), stainless steel conical strainer basket with flex stem and rubber stopper, C.P. brass, 1-1/2” O.D. tailpiece.
Chicago #STC-11-11-AB Heavy Duty lead-free, loose key stops and supplies with flexible riser and flange.
Zurn #Z-1180, Josam series 61030 or equal fixture trap type solids interceptor in lieu of trap, top access, gasketed cover, removable galvanized steel basket and stainless steel screen. See specification section 2.16 for additional information. Coordinate with casework manufacturer and Architect for installation.

P17 Wall Mounted Eyewash: Guardian Equipment model #GBF1721 Barrier-Free WideArea™, Eye/Face Wash, Wall Mounted, Stainless Steel Bowl and Skirt.

ADA Compliance: When installed at recommended mounting height, unit complies with ADA requirements for accessibility by handicapped persons (maximum height and reach, minimum knee clearance and distance from obstructions).

Spray Head Assembly: Four GS-Plus™ spray heads. Each head has a “flip top” dust cover, internal flow control and filter to remove impurities from the water flow.

Valve: 1/2" IPS brass stay-open ball valve. Valve is US-made with chrome plated brass ball and PTFE seals.

Bowl: 11-1/8" diameter stainless steel with wrap-around skirt. **Mounting:** Welded stainless steel wall bracket.

Supply: 1/2" NPT female inlet.

Waste: 1-1/2" OD chrome plated brass tailpiece.

Sign: ANSI-compliant identification sign.
Quality Assurance: Unit is completely assembled and water tested prior to shipment

P18 Wall Hung Two-User Washfountain - Handicap: The modular multiple lavatory system shall be Bradley Terreon® Wall-Hung Quadra-Fount® Washfountain model #MF2949/STD/IRP/LSD/TMA/CHAR or approved equal by Sloan Valve Company, Intersan or Willoughby Industries, Inc.. Multiple lavatory systems shall accommodate one (1) to four (4) users at a time. The pre-assembled bowl and sprayhead module is equipped with four

independent streamfomers, each controlled by a separate infrared sensor. Operating water pressure range is 20 – 80 PSI. A flow restrictor keeps the flow rate constant under any pressure.

1. Construction - Bowl & Pedestal: constructed of Terreon®, a densified solid surface material composed of bio-based resin, or Terreon®RE, a densified solid surface material composed of a bio-based resin preconsumer recycled granules. Terreon and TerreonRE are resistant to chemicals, stains, burns, and impact. Surface damage can be easily repaired with everyday cleansers or fine grit abrasives. Terreon and TerreonRE are GREENGUARD® certified as low-emitting materials. Pedestal frame and access panel are constructed of heavy gauge type 304 stainless steel.
2. Construction – Vandal Resistance: The sprayhead is molded as an integral part of the bowl. All streamformers, escutcheons, pushbuttons/infrared sesnsors are secured from inside the sprayhead. All valves, water supplies, and waste connections are concealed inside the pedestal. The front access panel is removable only with a hex key. The Terreon and TerreonRE bowls are resistant to stains, burns and impact. Surface damage is easily repaired and repair work is virtually undetectable.
3. In addition to the bowl and pedestal, the following valves and fittings are standard: Navigator® thermostatic mixing valve with stop valves, flexible stainless steel supply hoses, drain spud, and lock nut. Stop valves mounted onto nominal copper tubing.
4. Activation Types – Infrared: Each of the streamformers is controlled by a separate slow-closing solenoid valve. Hands placed within the bowl are detected by an infrared sensor which activates a flow of tempered water from one station at a rated of 0.50 GPM. Shut-off is automatic after hands are removed from the detection area. The infrared sensor uses a conical-shaped transmitting beam, having a detection area adapted to, but not exceeding, the bowl perimeter. The adaptive infrared sensor automatically adapts to the bowl after power is turned on. The infrared sensor is not affected by varying color tones or darkness. Direct sunlight or bright washroom lights will not activate the system. Infrared models also include solenoid valves and a low-voltage transformer as standard equipment.
    a. Solenoid – 12VDC, 3/8” tube fitting.
    b. Low-Voltage Plug-In Adapter – UL Listed 120VAC/12VDC plug-in adapter. Plugs into a standard GFCI protected electrical outlet. Location of plug-in adapter per local electrical code.
5. Barrier Free: The Terreon and TerreonRE Wall-Mount Quadra-Founts are designed to comply with the most current ADA and TAS guidelines on reaches, clearances and operation when mounted at recommended height dimensions by the installer.

Chicago #STC-11-11-AB Heavy Duty lead-free, loose key stops and supplies with flexible riser and flange. 1-1/4” x 1-1/2” polished chrome plated cast brass adjustable “P” trap, cleanout plug, extension to wall with escutcheon.

P19 Countertop Sink – Exam Room - Handicap: Elkay model #LRADQ1919-65-3 “Lustertone” 19-1/2”x19” nominal, single 16”x13-1/2” bowl, 18-gauge type 304 stainless steel, self-rimming countertop sink; highest quality; seamlessly drawn from nickel bearing stainless steel; bowl depth = 6-1/2”; 1-3/4” radius coved corners; exposed surfaces hand blended to a lustrous highlighted satin finish; bowl and faucet deck are recessed 3/16” below outside edge of sink; underside fully protected by a heavy duty Sound Guard undercoating; 3-1/2” drain opening; faucet holes on 8” centers; 3 faucet holes; Quick-Clip.
Chicago Faucets model #201-A3I7ABCP deck mounted 8” fixed centers concealed hot and cold water sink faucet, 9-1/2” L type swing spout, 2.2 GPM aerator, 4” vandal proof wrist-blade handles, Quaturn compression operating cartridge, ½” NPSM supply inlets and coupling nut for 3/8” or ½” flexible riser, ECAST design for reduced lead content.
Elkay model #LK35 Standard Cup Strainer, fits 3-1/2” opening (4-1/2” top diameter), stainless steel conical strainer basket with flex stem and rubber stopper, C.P. brass, 1-1/2” O.D. tailpiece.

Chicago #STC-11-11-AB Heavy Duty lead-free, loose key stops and supplies with flexible riser and flange. 1-1/2" x 1-1/2" polished chrome plated cast brass adjustable "P" trap, cleanout plug, extension to wall with escutcheon.

P20 Exposed Floor Mounted Combination Emergency Shower and Eye/Face Wash: Chicago Faucets mode #8405-NF Floor Mounted Combination Eye/Face Wash and Drench Shower Wheel Chair Accessible Combination Eye/Face Wash and Safety Drench Shower with Stainless Steel Pull Rod; 1-1/4" NPT Female Thread Inlet; 1-1/4" NPT Female Thread Outlet; Anti-corrosive polyamide 11 plastic coating in high-visibility yellow color; Floor mounted; Eyewash assembly in ABS plastic; Eyewash bowl in ABS Plastic; Two high-flow aerated water spray at low pressure with automatic opening anti-duct cover; Brass fittings and galvanized pipe construction; Pull handle for activation; Shower head in ABS Plastic; High-visibility photoluminescence safety sign with green background and white text for easy identification; Maintenance card for recording periodic testing and Certified to the ANSI Z358.1 Standard for Emergency and Shower Equipment.

P21 Wall Hung Bariatric Lavatory - Handicap: Willoughby Industries model #BHS-3123-NV-4CC ADA-Compliant Solid Surface Bariatric Lavatory. Floor mounted bariatric lavatory shall accommodate bariatric patient and be able to withstand a static downward force of 1,000 LBS at front edge of lavatory with no permanent physical damage. Lavatory deck shall be constructed of Aquasurf molded cast polymer densified solid surface material composed of polyester/acrylic resin, UV stabilizer, aluminum trihydrate and mineral fillers. Lavatory deck shall have an integral D-shaped bowl with an integrally cast 4" cove backsplash and 4" apron included. Lavatory pedestal shall be welded stainless steel; exterior panels shall be solid polymer. Optional wood grain exterior panels available.
The bariatric lavatory shall be supplied with a 4" centerset rigid 8" gooseneck wristblade faucet and an antimicrobial drain and offset tail piece.

P22 Adult Daily Living Sink – Non-Handicap: Elkay model #ELU281610 "Lustertone" Undermount Sink 30-1/2"x18-1/2" overall, single 28"x16" bowl, 18-gauge type 304 stainless steel, under- counter mounted sink; highest quality; seamlessly drawn from nickel bearing stainless steel; bowl depth = 10"; 1-3/4" radius coved corners; exposed surfaces hand blended to a lustrous highlighted satin finish; underside fully protected by a heavy duty Sound Guard undercoating; 3-1/2" drain opening; template and countertop mounting clips are included.
Chicago Faucets model #201-AGN2AE3ABCP sink faucet for hot and cold water, concealed deck mount with 8" fixed centers, chrome plated; rigid/swing gooseneck spout, 5-1/4" center-to-center; 2.2 GPM pressure compensating Softflo aerator; 2-3/8" metal, vandal-proof, lever handles with sixteen point, tapered broach and secured blue and red index buttons; Quaturn™ rebuildable compression cartridge, opens and closes 90°, closes with water pressure, features square, tapered stem; ½" NPSM supply inlets and coupling nut for 3/8" or ½" flexible riser; ECAST® construction with less than 0.25% lead content by weighted average; ADA compliant, Certified to NSF/ANSI 61.
Elkay model #LK35 Standard Cup Strainer, fits 3-1/2" opening (4-1/2" top diameter), stainless steel conical strainer basket with flex stem and rubber stopper, C.P. brass, 1-1/2" O.D. tailpiece.
Chicago #STC-11-11-AB Heavy Duty lead-free, loose key stops and supplies with flexible riser and flange.
Furnish and install food waste grinder for this sink as follows:

1. Food Waste Disposer shall be In-Sink-Erator Badger® 5 or approved equal. The disposer shall be continuous geed, with ½ HP motor, galvanized steel grinding elements with two stainless steel 360° swivel lugs. The disposer shall be furnished with a self-service wrench.
2. Disposer shall have a 2-year parts and in-home service warranty.

P23 Washer Supply/Drain: Symmons model #W-602-X Laundry-Mate supply and drain unit with ½" supplies and 2" drain with integral stops and recessed wall box with wall plate.

P24 Whirlpool: Provide Whitehall Mobile Whirlpool model #S-110-M with a 110-gallon capacity, 56"L x 24"W x 25"D, or approved equal. Whirlpool shall be fabricated from heavy gauge, type 304 stainless steel. Construction shall be seamless welded and exposed surfaces shall be polished to satin finish. Bottom of tank shall be a seamless, rounded coved design to minimize bacteria build up. Whirlpool shall have heavy duty swivel casters with locking device on rear pair of casters. Provide a turbine assembly with raising and lowering device which functions both as agitator and emptying device, permits adjustment of desired height, direction of water agitation, and can be locked into place. Turbine assembly shall be UL listed 1/2 HP jet pump motor with automatic thermal overload protector and lifetime-sealed bearings. Provide a thermometer with a stem retainer to prevent rattling when whirlpool is in operation.
Provide Whitehall Manufacturing Whirlpool Mixing Valve model #MXT15-OTG-SMC. Mixing Valve Assembly shall be factory assembled and tested. The Thermostatic Mixing Valve shall comply with ASSE and CSA standards. Valve shall contain a copper encapsulated, paraffin-based Thermal Actuator. Valve shall be a chrome plated, solid DZR brass body with a capacity of 15 GPM at 45 PSI differential and a maximum operating pressure of 125 PSIG. Supply pressure variation shall be up to 20%. Valve shall have a maximum outlet temperature of 110°F. Assembly shall include an outlet temperature gauge, lockable inlet and outlet ball valves and a vacuum breaker. Valve shall comply with ASSE 1069, ASSE 1070 and CSA B125.3 standards. Provide surface mounted cabinet for the valve.

P25 Wall Mounted Eye-Face wash: Bradley model #S192240D1BBAA00 Wall-Mount Halo™ Eye/Face Wash.

- Pipe & Fittings: Piping to 1//2" NPT water supply inlet on unit. Piping to 1-1/4" NPT drain outlet for eyewash.
  1-1/4" piping assembly manufactured of one of galvanized steel with BradTect® safety yellow coating.
- Ball Valve: ½" stay-open eye/face wash valve manufactured of chrome plated brass.
- Eye/Face Wash: The Halo eye/face wash system offers a high performance rinsing platform the provides rapid relief to an individual eye and face that have been injured by chemicals or particulate. This system provides the most complete face wash available in the market. The eye/face wash includes an integral 5.1 GPM flow control, providing water at a safe velocity while maintaining its effectiveness (exceeds minimum water flow of 3.0 GPM at 30 PSI). Eye/face wash is protected by a full bowl dust cover that activates the unit when it is opened. Safe, steady water flow under varying waer supply conditions from 30-90 PSI is assured by integral flow control in the sprayhead assembly Sprayheads are made form an impact resistant ABS plastic. Dust cover is constructed of transparent yellow impact-resistant plastic.
- Backflow Prevention: Series n9 dual-check backflow preventer has a chrome-nickel plated brass body and includes atmospheric vent for continuous pressure applications. The check valve comes with 3/8" female dual NPT female inlet and outlet connections. It can sustain a maximum pressure of 125 PSI. The check valve is certified to CSA B64.8.
- Wall Bracket: Heavy-gauge sand cast aluminum protect with BradTect® safety yellow coating. Includes three clearance holes for mounting bracket onto wall (mounting hardware not included).
- Waste: 1-1/4" drain fitting and tailpiece furnished.

P26 Recessed Eyewash Unit: Guardian model #GBF1735DP Swing-Down Eye/Face Wash with Drain Pan, Recess Mounted.

1. **Application:** Recessed barrier-free swing-down eye/face wash with drain pan. Stainless steel cover provides attractive appearance and protects unit when not in use. When activated, cover serves as pan to collect waste water and return it into unit for drainage.

2. **ADA Compliance:** When installed at recommended mounting height, unit complies with ADA requirements for accessibility by handicapped persons.
3. **Spray Head Assembly:** Two FS-Plus™ spray heads mounted on supply arms. Each spray head has individually adjustable flow control and filter to remove impurities from water flow.
4. **Cover/ Drain Pan:** 16 gauge stainless steel combination cover and drain pan. Grasping "panic bar" handle and opening cover pulls spray head assembly down from vertical to horizontal position, activating water flow. While unit is in operation, waste water is collected in drain pan and returned into cabinet for drainage. Unit remains in operation until cover is returned to closed position.
5. **Valve:** 1/2" IPS brass plug-type valve with O-ring seals. Furnished with in-line strainer to protect valve and spray heads from debris and foreign matter.
6. **Mounting:** 16 gauge stainless steel cabinet with flange featuring 3/8" return for recessed mounting in wall. Unit fits in standard 3-5/8" deep wall.
7. **Supply:** 1/2" NPT female inlet. **Waste:** 2" NPT female outlet.
8. **Sign:** ANSI-compliant identification sign.
9. **Quality Assurance:** Unit is completely assembled and water tested prior to shipment.

P27 Floor Mounted Bariatric Water Closet - Handicap: Willoughby Industries model #BETF-1490-FM-FA-12" Bariatric, 12" Rough-in, Front Mounted, Floor Outlet, Floor Mounted, Siphon Jet Series Toilet. Fixture shall be fabricated from heavy gauge, Type 304 stainless steel. The construction shall be all-welded. Fixture exterior shall have an antimicrobial gloss white powder coat enamel finish. Toilet bowl interior shall have a sanitary bead-blast stainless steel finish. Standard toilet shall include:

- Elongated toilet bowl with integral contoured seat
- Integral crevice-free self-draining flushing rim with positive afterfill and fully enclosed 2-3/8" OD trap which shall maintain a minimum 3-1/2" seal.
- Toilet shall be siphon jet which requires 35 PSI minimum flushing pressure.
- Hinged toilet seat shall have open front with cover and be rated for a 1200 pound weight capacity.
- Toilet hinges are stainless steel, seat and cover shall be white in color.
- Unit will pass a 2" ball.
- Anchoring shall be from the front thru (2)12"x12" removable access panels. The fixture is provided with four (4) ¾" wall carrier mounting holes and one (1) floor mounted 'Z' clip mounting bracket. Wall and floor anchoring hardware is by others (i.e. Plumbing to furnish and install).

The fixture shall withstand loadings up to 2000 pounds with no measurable deflection and loadings up to 5000 pounds with no measurable damage.
Sloan Royal model #111-1.28; exposed water closet flushometer for floor mounted or wall hung top spud bowls. Flushometer shall be quiet, exposed, diaphragm type, chrome plated for left or right hand supply, water closet type with the following features:

- PERMEX™ synthetic rubber diaphragm with dual filtered fixed bypass.
- ADA compliant metal oscillating non-hold-open handle with triple seal handle packing.

- 1” I.P.S. screwdriver Bak-Chek® angle stop with free spinning vandal resistant stop cap.
- Adjustable tailpiece.
- High back pressure vacuum breaker flush connection with one-piece bottom hex coupling nut
- Spud coupling and flange for 1-1/2” top spud.
- Sweat solder adapter with cover tube and cast wall flange with set screw.
- High copper, low zinc brass castings for dezincification resistance.
- Non-Hold-Open handle, fixed metering bypass and no external volume adjustment to ensure water conservation.
- Flush accuracy monitored by CID™ Technology.
- Diaphragm, stop seat and vacuum breaker molded from PERMEX™ rubber compound for chloramines resistance.

2.3 PLUMBING FIXTURES – OUTDOOR RESTROOM AND STORAGE BUILDING

A. Provide plumbing fixtures as specified herein. Fixture trim, traps, faucet, escutcheons and waste pipes exposed to view in finished spaces shall be I.P.S. brass with polished chromium plating over nickel finish. Fixtures shall have manufacturer's label or trademark indication first quality.

B. Fixtures with wall outlet flanges shall be set proper distance from floor or wall to make first-class joint with closet setting compound or gasket.

C. Mounting heights shall be as shown on architectural details.

D. Each individual fixture shall be provided with supply stops for each water service. Supply stops and supply risers shall be lead-free to meet NSF-61G.

E. Exposed piping below handicap lavatories and sinks shall be insulated with PVC coated insulation similar to Truebro LavGuard 2, McGuire Mfg. Co. Inc., Plumberex Specialty Products Pro-Extreme, or approved equal. The product shall be rigid high-impact, stain-resistant PVC, 1/8” constant wall thickness with internal ribs, have UV protection, and have an E-Z Tear-To-Fit trim feature. The color shall be china white and shall be Compatibility #100 series to fit all 1-1/4” or 1-1/2” cast brass or tubular P-trap assemblies and 3/8” or ½” angle stop assemblies.

F. Fixture Schedule: Unless otherwise specified, fixtures shall be as follows (Note: Manufacturers and Model numbers are provided to set standard of fixture) :

1. Stainless Steel Fixtures including Water Closets and Urinals with integral flush valves and Lavatories with integral faucets: Acorn Engineering Company, Metcraft Industries, Willoughby Industries Inc., Whitehall Manufacturing or equal.
2. Mop Receptor: Crane Plumbing/Fiat Products, Stern-Williams Co. Inc., Zurn ZPPG, E.L. Mustee & Sons, Florestone Products Co. or equal.
3. Mop Receptor Faucets: Moen Commercial, Crane Plumbing/Fiat Products, Stern-Williams, American Standard, Chicago Faucets, Speakman Co. or equal.

OSP-1 Water Closet (Non-Handicap - Public): Furnish and install Acorn Engineering Company Dura-Ware model #2105-W-1-1.6GPF-FVCH-ADA Siphon Jet Toilet. Fixture shall be fabricated from 16 gauge, type 304 stainless steel. Construction shall be seamless welded and exposed surfaces shall have a satin finish with an integral contoured toilet seat. Toilet shall be concealed siphon jet type with an elongated bowl and a self-draining flushing rim. Toilet shall meet ANSI 112.19.2M requirements, using a minimum average water consumption of 1.6 gallons per flush. Toilet trap shall have a minimum 3-1/2”

seal that shall pass a 2-1/8" diameter ball and be fully enclosed. Toilet waste outlet shall be gasketed waste. Connecting hardware provided by installer. Fixture specified shall include flush valve with wall supply (i.e. the flush valve shall be concealed behind the wall in the accessible plumbing chase).
Zurn Industries, Jay R. Smith, Josam or equal hub and spigot combined waste fitting and chair carrier supports, with adjustable extensions, rear foot support and face plate with foot support & feet bolted to floor, with seat mounting height to be 15" above finished floor.

OSP-2 Water Closet (Handicap - Public): Furnish and install Acorn Engineering Company Dura-Ware model #2105-W-1-1.6GPF-FVCH-ADA Siphon Jet Toilet. Fixture shall be fabricated from 16 gauge, type 304 stainless steel. Construction shall be seamless welded and exposed surfaces shall have a satin finish with an integral contoured toilet seat. Toilet shall be concealed siphon jet type with an elongated bowl and a self-draining flushing rim. Toilet shall meet ANSI 112.19.2M requirements, using a minimum average water consumption of 1.6 gallons per flush. Toilet trap shall have a minimum 3-1/2" seal that shall pass a 2-1/8" diameter ball and be fully enclosed. Toilet waste outlet shall be gasketed waste. Connecting hardware provided by installer. Fixture specified shall include flush valve with wall supply (i.e. the flush valve shall be concealed behind the wall in the accessible plumbing chase).
Zurn Industries, Jay R. Smith, Josam or equal hub and spigot combined waste fitting and chair carrier supports, with adjustable extensions, rear foot support and face plate with foot support & feet bolted to floor, with seat mounting height to be 18" above finished floor.

OSP-3 Urinal (Non-Handicap - Public): Furnish and install Acorn Engineering Company Dura-Ware model #2158-W-1-FVCH Stainless Steel Urinal. Urinal mounted at 17" rim height to comply with ANSI, ADA and UFAS accessibility requirements. Interior to have a contoured surface to facilitate cleaning. Fixture shall be fabricated of 18 gauge with 16 gauge bowl type 304 stainless steel with exposed surfaces polished to a satin finish. Fixture specified shall include flush valve with wall supply (i.e. the flush valve shall be concealed behind the wall in the accessible plumbing chase)
- (0.5 GPF).
Zurn Industries, Jay R. Smith, Josam or equal hub and spigot combined waste fitting and chair carrier supports, with adjustable extensions, rear foot support and face plate with foot support & feet bolted to floor, with rim mounting height to be 24" above finished floor.

OSP-4 Urinal (Handicap - Public): Furnish and install Acorn Engineering Company Dura-Ware model #2158-W-1-FVCH Stainless Steel Urinal. Urinal mounted at 17" rim height to comply with ANSI, ADA and UFAS accessibility requirements. Interior to have a contoured surface to facilitate cleaning. Fixture shall be fabricated of 18 gauge with 16 gauge bowl type 304 stainless steel with exposed surfaces polished to a satin finish. Fixture specified shall include flush valve with wall supply (i.e. the flush valve shall be concealed behind the wall in the accessible plumbing chase)
- (0.5 GPF).
Zurn Industries, Jay R. Smith, Josam or equal hub and spigot combined waste fitting and chair carrier supports, with adjustable extensions, rear foot support and face plate with foot support & feet bolted to floor, with rim mounting height to be 17" above finished floor.

OSP-5 Wall Hung Lavatory (Handicap - Public): Furnish and install Acorn Engineering Company Dura-Ware model #1953-1-DMS-4-H24-GE-OF-LC 18" wide Lavatory. Fixture shall be fabricated from heavy gauge, type 304 stainless steel. Construction shall be seamless welded with a satin finish exterior. Lavatory deck shall have an integral air-circulating, self-draining soap dish. Lavatory angle braces and fasteners shall be furnished by manufacturer. Installation shall be made in accordance with manufacturer's recommendation and details. Units to conform with ANSI, UFAS and ADA requirements for accessibility.

Fixture shall be provided with deck mounted spout, air control hot and cold water valve, 4" centerset faucet holes, grid strainer with close elbow (1-1/4"), and lavatory overflow.
McGuire heavy duty polished chrome-plated cast brass angle valve kits, loose key, flexible risers, escutcheons. 1-1/4" x 1-1/2" polished chrome plated cast brass adjustable "P" trap, cleanout plug, extension to wall with escutcheon. Grid drain.
Concealed arm carrier support with foot support to suit construction. Install with rim at 34" maximum above finished floor.
Insulate cold water, hot water, and waste beneath lavatory.

OSP-6 Floor Mounted Mop Receptor: Fiat model #MSBID-3624 molded stone mop service basin, 36"x24"x10"D, 1" wide shoulders; factory installed drain body shall be stainless steel and designed to provide for a lead caulk or QDC-3 joint to a 3" drain pipe.
Chicago model #445-897S-XKRCCP service sink faucet with integral check and stops, cast brass spout with VB and pail hook, 8" centers .
Fiat Mop Hanger #889-CC; 24" long by 3" wide, stainless steel attached with three (3) rubber tool grips.
Fiat Hose and Hose Bracket #832-AA; 30" long flexible, heavy duty, 5/8" rubber hose, cloth reinforced, with ¾" brass coupling at one end. Bracket is 5" long by 3" wide. 18 gauge #302 stainless steel with rubber grip.

2.4 KITCHEN EQUIPMENT

A. Kitchen equipment shall be set in place by the Kitchen Equipment Subcontractor.

B. The Plumbing Subcontractor shall provide hot and cold water, natural gas, drainage, waste and vent to each of these fixtures as required and make final connections to same.

C. The Plumbing Subcontractor shall furnish and install shut-off valves at each fixture and, where required, shall provide unions to permit the removal of fixtures for repairs. All hot and cold water piping, valves, waste and vent piping to Kitchen Equipment exposed to normal view, including piping under exposed counters, shall be chrome-plated brass pipe or chrome-plated copper tubing after fabrication.

D. The Kitchen Equipment layout plans show the approximate size, number, and locations of connections for each item of Kitchen Equipment. The Plumbing Subcontractor is advised that the size, number, and arrangement of connections may vary with different manufacturers. This Contractor shall make the connections no smaller than those provided at the fixture and shall vary the arrangement to suit the equipment furnished. The Kitchen Equipment Subcontractor shall furnish certified roughing-in drawings to the Plumbing Subcontractor before proceeding with the work. Verify and coordinate all floor drain and floor sink locations with the kitchen equipment contractor before they are set.

E. The following items and those indicated on the Drawings shall be furnished and installed by the Kitchen Equipment Contractor, but the Plumbing Subcontractor shall make all connections, hot and cold water, gas, waste (direct or indirect), and vent piping, thereto and provide necessary traps, shut-offs, thereof:

Hand Sinks	Floor Troughs w/ Cooling Water	Ice Maker with Bin
Prep Tables w/ Sinks	Work Tables w/ Sinks	Water Filtration Systems
Quick Switch Hot-Cold Food Wells	Soiled Dishtable & 3-Bay Pot Sink	
40 Gallon Tilting Skillets	Cooler Coils	Freezer Coils
Conveyor Dishmachine	Pre-Rinse Assembly	Coffee Brewer
Disposers & Controls	Roll-In Combi Ovens	Mop Sink

Utility Distribution System	Hot Chocolate Dispenser & Water Filter
60-Gallon Tilting Kettle	Reverse Osmosis Water Filtration Systems

F. The Kitchen Equipment Subcontractor shall furnish all faucets, strainers, lever handle wastes and waste outlets required on equipment; all furnished equipment shall be installed by the Plumbing Subcontractor. All other specialty items such as tailpieces, traps, valves, and shut-offs, shall be furnished and installed by the Plumbing Subcontractor.

G. The dishmachine shall have a backflow preventer installed on the incoming hot water supply piping. Also, there shall be non-testable dual check backflow preventers with vacuum breaker installed near the 3-compartment pot sinks on both the cold and hot water taps for connection by the soap/sanitizing subcontractor. The backflow preventer are shown on the drawings.

H. Several pieces of cooking equipment require water filtration systems and are shown on the drawings. These are furnished by the Kitchen Equipment Contractor, but the Plumbing Subcontractor shall install and pipe them. They are typically located on the wall or metal panel behind the equipment, but the reverse osmosis systems for the Roll-In Combi Ovens will be mounted in the Janitor's Closet at piped to the equipment.

I. The Kitchen Equipment have no gas connections…it is all electric.

2.5 LABORATORY EQUIPMENT

A. All mechanical service fixtures, fittings, and related items shall be furnished under the scope of work of this section, whether itemized or not and shall be of best quality. Specialized laboratory fixtures shall be used on science furniture and fixtures, shall be of red brass with a copper content of 81%. All water valves shall be manufactured using NSF 61 Lead-Free Brass alloys. Fixtures used in connection with furniture other than science furniture shall be good quality domestic fixture of modern design. All fixtures shall be in chromium plated finish over nickel and copper, unless specifically specified to be chemical-resistant metallic bronze finish. All sinks have overflow drain, so pipe accordingly.

B. Laboratory water fixtures shall be ½" I.P.S., unless otherwise specified, and shall have lever handles or ADA compliant wrist blade handles as specified. Water valves shall use interchangeable cartridge designs with all wearable parts self-contained. Gooseneck spouts shall be extra heavy seamless brass tubing with vacuum breakers as manufactured by Chicago Faucet, T & S Brass, Zurn ZPPG, WaterSaver Faucet Company, Moen Commercial or equal. Student Table, Demonstration Table and Prep Room Sinks shall have faucets similar to the models called out in section 2.5.J.

1. Sinks with two faucets shall be one water single faucet and one water single faucet with aspirator on the nozzle.

C. Removable serrated hose ends shall be provided on all water fixtures in accordance with the equipment list. Where indicated, serration shall be so designed as to hold hose securely. These shall be furnished in addition to the aerators for Owner's optional use.

D. Spring flow aerators are to be furnished on all water fixtures.

E. Laboratory Gas valves shall be AGA certified, Massachusetts Plumbing Board approved ball valve type with integral serrated nozzle and internal check valve. 3/8" ips quarter-turn design with an ADA compliant lever handle. Valve to be rated for 125psi max working pressure. All single gas turrets shall be similar to Chicago Faucet model #LGB1-31C-50 or equal Straight Pattern Ball Valve. These shall have straight serrated nozzles with check valve, metal level

handles, index button for natural gas service, straight wall flange and shanks, solid brass valve construction and shall be fully assembled and tested. Equivalent manufacturers are T & S Brass, WaterSaver Faucet Company, or equal.

F. Tank nipples shall be furnished where required to anchor fittings to laboratory furniture and shall provide a tapered pipe thread running into a thread to allow use of lock nut and still provide leakproof joints.

G. Colored index buttons shall be provided to designate type of service on all mechanical service fixtures and both color and lettering shall be provided in button which shall be located in top of handles of fixtures. Color designations shall be as follows:

Lab Hot Water – Red Button with White “H”
Lab Cold Water – Blue Button with White “C’
Lab Gas – Green Button with White “G”

All indexes shall be of the colored plastic material and indented letters shall be filled with enamel in contrasting color.

H. Crump cup strainers of stainless steel shall be provided at stainless steel sinks. Provide tailpieces for stainless steel sinks.

I. Vacuum breakers are required where serrated hose tips are furnished, shall be chrome plated brass, and shall be either Chicago Faucet, Opmax or Watts Regulator Company LF-9 backflow preventer as required by area plumbing code. Vacuum breakers shall be installed between the control valve and the outlet of the fixture and, when area code requires vacuum breaker to be installed in an elevated position, piping necessary to connect valve, vacuum breaker, and hose shall be by this Contractor. Where vacuum breakers are required by area code, those mechanical service fixtures not requiring a hose connection shall not have vacuum breakers but shall be provided with devices acceptable to the code authorities that will prevent under any circumstances the connection of a hose.

J. Laboratory Plumbing Fixtures as scheduled required the following faucets or gas turrets and are as follows (note that model numbers provided are for reference and shall be used as a standard only). Also, note that the single air and gas turrets in the students tables are not listed and are specified above/:

1. L1: Student Table Sink – One (1) Cold Water Only Faucet Chicago Faucets model #LWS1-A11-A or equal deck mounted, single inlet water faucet with ½-turn compression cartridge, metal wrist blade handle with cold water button, 5-1/4” rigid/swing gooseneck spout and straight serrated nozzle, solid brass valve construction. Also, one (1) Cold Water Only Deck Mounted Faucet Chicago Faucets model #LWS1-A31-A with aspirator or equal deck mounted, single inlet water faucet with ½-turn compression cartridge, metal wrist blade handle with cold water button, 5-1/4” rigid/swing gooseneck spout and straight serrated nozzle with Aspirator, solid brass valve construction.
2. L2: Student Table Sink (Handicap) - One (1) Cold Water Only Faucet Chicago Faucets model #LWS1-A15-A or equal deck mounted, single inlet water faucet with ½-turn compression cartridge, metal wrist blade handle with cold water button, 5-1/4” rigid/swing gooseneck spout and straight serrated nozzle, solid brass valve construction.
3. L3: Demonstration Table Sink – One (1) Mixing Faucet Chicago Faucets model #LWM2-A13-A 8” centerset deck mounted dual inlet water faucet with ½-turn compression cartridge, metal wrist blade handles with hot and cold water buttons, 5-1/4” rigid/swing gooseneck spout and straight serrated nozzle, solid brass valve construction.

4. L4: Hand Wash and Prep Room Sink - One (1) Mixing Faucet Chicago Faucets model #LWM2-A13-A 8" centerset deck mounted dual inlet water faucet with ½-turn compression cartridge, metal wrist blade handles with hot and cold water buttons, 5-1/4" rigid/swing gooseneck spout and straight serrated nozzle, solid brass valve construction.
5. L5: Emergency Shower/Eyewash/Facewash – One (1) Guardian model #GBF2150 recessed laboratory unit: wall mounted combination eye/face wash and safety drench shower, wheelchair accessible combination eye/face wash and safety drench shower with integral pull handle.
6. L6: Emergency Shower/Eyewash/Facewash – One (1) Chicago Faucets model #8405-NF floor mounted combination eye/face wash and drench shower, wheelchair accessible combination eye/face wash and safety drench shower with stainless steel pullrod by Plumbing Subcontractor.
7. L7: Pass-Thru Fume Hood - Integral faucet, gas turret and manual controls

K. Science Room Fixture L-5 shall have the following features:

1. SSBF-44* – Barrier Free, recessed, wall mounted combination eye/face wash and shower safety station with ceiling mounted exposed shower head, patented stainless steel shower-actuating arm and swing-down stainless steel combination eye/face wash drain pan. Unit construction shall be welded 16-gauge type 304 stainless steel with #4 brushed satin finish. Unit shall include stainless steel shower head, internal 20 GPM flow control, supply nipple, escutcheon, chrome-plated brass eye/face wash supply fittings, brass unions, and U.S made full-port brass ball valve for shower. Eye/face wash valve shall be AutoFlow™, plug-type design with PTFE coated O-rings to seal valve orifices, polypropylene FS-Plus™ spray heads with individual 3.2 GPM flow controls and polyurethane filters. Supplied with in-line strainer to protect eye/face wash valve and spray heads from debris in water line, and 2" IPS drain. Activate eye/face wash valve by rotating 90° from stored position. Unit shall include ANSI compliant sign.
2. Performance: Unit complies with ADA requirements for accessibility by handicapped persons. Unit shall be fully factory assembled and hydrostatically tested to meet or exceed ANSI Z358.1 – 2014, and come with a full 2-year warranty.
3. Equal manufacturers to Guardian Equipment are Chicago Faucets, Bradley & Encon.

L. Science Room Fixture L-6 shall have the following features:

1. Combination Eye/Face Wash and Drench Shower
2. 1-1/4" NPT Female Thread Inlet
3. 1-1/4" NPT Female Thread Outlet
4. Anti-corrosive polyamide 11 plastic coating in high-visibility yellow color
5. Floor Mounted
6. Eyewash assembly in ABS plastic
7. Eyewash bowl in ABS Plastic
8. Two high-flow aerated water spray at low pressure with automatic opening anti-dust cover
9. Brass Fittings with Galvanized Pipe Construction
10. Push Handle for activation
11. Pull Rod for activation
12. Shower head in ABS Plastic
13. High-visibility photoluminescence safety sign with green background and white text for easy identification
14. Maintenance card for recording periodic testing
15. Wheel Chair Accessible
16. Certified to the ANSI Z358.1 Standard for Emergency Eyewash and Shower Equipment

M. Single Zone Valve Box Assemblies for Emergency Gas Shut-off Valves at Science Classrooms: Similar to Isimet LSP – Laboratory Service Panel for Natural Gas System

1. CONTROL PANEL: At each science classroom as shown on Drawings, provide an ISIMET – LSP2211-3 –T Laboratory Service Panel. Panel shall have brushed stainless steel door panel and trim with gray powder coated enclosure provided with low voltage transformer and fuse block. Enclosure shall be NEMA 1 rated. Panel shall be labeled "NATURAL GAS SERVICE PANEL". Panel shall comply with UL508-A, Standards for Industrial Control Panels.

   a. Panel shall have integral printed circuit board with logic device to provide 24-vac output circuit to activate integral 24-vac natural gas solenoid. Activation of output circuit shall be enabled only by switch ON and then keying.

   b. The Panel shall be equipped with a service switch and a momentary enabling key switch. Deactivation of output circuit shall not require engagement of enabling key. Panel shall be provided with N/O momentary panic button assembly to deactivate output circuit in case of emergency. Reset after panic shall occur by re-keying. Green LED shall indicate operation ON. Red LED shall indicate that shut-down has occurred due to pressing the panic button.

   c. Provide panel with dry contact terminals for output integration. ISIMET "Panic" shall provide a notification signal to a secondary alarm monitoring system. Reset of Service Panel shall withdraw notification signal.

2. SOLENOID: Service Panel shall be furnished with ISIMET Series 303 normally closed natural gas specific zero differential solenoid. Solenoid coil shall be 24-vac. Solenoid shall be UL listed. Service Panel shall be provided with a ball valve up-stream from solenoid. Thoroughly clean piping system prior to placing into service.

3. WIRING: Do not install wiring or cable for integrated systems, remote panic assemblies, fuel gas sensors or other interface wiring within conduit for either 24-vac control or 120-vac line voltage. Each wiring system should be housed in independent conduit and not bundled with wiring for other systems.

   a. Line and 24-vac control wiring furnished and installed by Electrical Subcontractor.

4. Emergency Gas Shut-Off Panel shall be Isimet, American Gas Safety, Mapa Products, Asco, or approved equal.

N. Alternate Single Zone Valve Box Assemblies for Emergency Gas Shut-off Valves at Science Classrooms, similar to American Gas Safety products:

1. MERLIN UTILITY CONTROLLER: At each science classroom and elsewhere as shown on Drawings, provide a Utility Controller with fascia panel mounted switches to activate remote solenoids and relays to control natural gas, domestic water and electrical convenience outlets or other indicated services or devices. Utility Controller shall comply with Underwriter's Laboratory UL61010-1 3rd Edition Standards. Controller shall have integrated printed circuit board and Microprocessor with adaptable programming features. Controller shall utilize and operate a pressure transducer to perform a pressure drop test on the natural gas line before allowing gas to be supplied. Controller shall continuously check incoming gas supply pressure throughout operation. Controller shall provide line voltage signals for output circuits. Controller shall provide inputs for remote EPO's and Gas Sensors. The Controller shall be equipped with an Authority Key Lock

that restricts activation of output signals to the instructor or educator. Controller shall be provided with a fascia mounted EPO button. Output signals will require Key Lock authority for re-set.

2. SOLENOID VALVE: At each science classroom and where shown on Drawings, provide UL approved solenoids for Gas services. All solenoids shall be normally closed and fail closed on loss of power. Number of solenoids, intended use and pipe sizes are as noted in Equipment Schedule or Drawings. The gas solenoid valves shall be accessible.

3. REMOTE PANIC BUTTON: Where shown on Drawings and where classroom size and configuration restricts clear path from work areas to Utility Controller, provide a wall mounted Remote Panic Button. Assembly shall be located as shown on Drawings and as stipulated in Equipment Schedule. Integrate assembly with low voltage input on Controller. Note that some of the Science Labs require two (2) remote panic buttons.

4. FUEL GAS SENSOR: Where shown on Drawings and in Equipment Schedule, furnish and install a AGS Merlin Fuel Gas Sensor in order to detect raw fuel gas within the classroom. Integrate Fuel Gas Sensor with the Controller.

O. The Plumbing Contractor shall provide an additional electrical relay enclosure for the science labs connected to the natural gas shut-off system. The manufacturers shall be the same for each enclosure. The intent is that if the gas is shut off in an emergency either at the gas panel or the remote shut-off button, then the electrical system will also be shut off as well. The electrical subcontractor shall wire the electrical relay enclosure.

P. Alternate manufacturer for laboratory gas shut-off and electrical relay enclosure is Lab Automation Control Systems by E&I. Ensure that it is MA Product Approved.

Q. In addition, non-emergency shut-off valves shall be installed in an accessible location for each individual table, bench, or hood equipped with gas outlets per 248 CMR 5.07. For this project, these shall be provided where they serve multiple gas outlets along a row of benches. These shall be similar to the following:

1. American Gas Safety model #AGS-MBENC1084 Flush Mount Ball Valve Enclosure Ready Access with Trim. This shall be powder coated white, 10”x8”x4” flush mount enclosure with pre-drilled pipe access and mounting holes. Enclosure provides 1.25” decorative trim with additional holes for pipe support fittings.

2. Alternate products are by Acudor model #ARVB Recessed Valve Box, Elmdor Recessed Mounted Valve Lock Box, nVent Hoffman Flush Mount Door Frames, or approved equal.

2.6 PIPE MATERIALS

A. All soil, waste, kitchen waste, vent and storm drain lines in accessible areas 2 in. and larger shall be cast-iron "no-hub," ASA group 022 pipe and fittings joined with "Clamp-All," or equal; on pipe sizes 3 in. and larger, use four (4) band clamps, two (2) band clamps will only be allowed on 2 in. pipe. All buried soil, waste, vent, and storm lines shall be service weight cast-iron pipe with all fittings carefully fitted and caulked together with oakum and lead, sealed gas and watertight. Minimum size of piping below ground shall be 2 in. Where it is impractical to install cast-iron pipe, as in tight partition work or where the sizes of lines are smaller than 2 in., Type "L" copper tubing shall be used conforming to ASTM Specification with sweat type fitting using lead free solder and non-corrosive flux, "Non-Korrode," or approved equal, conforming to ASTM Specification B-32 alloy 50A. In lieu of oakum and lead joints, "push on type" resilient gasket fittings may be used on buried pipe only.

1. Furnish and install hubless soil pipe couplings designated Heavy Weight (HW), made of extra wide, heavy duty corrugated type 304 stainless steel with axially slotted heavy duty, worm drive clamps tightened to 80 in lbs. of torque. Flanged gaskets to be made of neoprene rubber, meeting the requirements of ASTM C 564, with sealing rings under each stainless steel clamp. Manufacturers shall be Mission Heavy Weight, Husky 4000, Clamp-All 125, Ideal Clamp Products, or equal.

2. Any piping serving the garage waste system (GW) which discharged through a gas-sand trap system be as specified above. No DWV copper piping is allowed on this piping system.

3. All below grade sanitary waste and kitchen waste piping shall slope at 2% or ¼" per foot.

B. All vent lines 2 in. and smaller shall be Type "L" copper, or DWV, except minimum size below ground shall be 2 in. Minimum vent terminal through roof shall be 3 in. Vent flashing at the roof shall be by the Roofing Subcontractor.

C. All hot water, cold water, tempered water, laboratory water, hot water recirculating piping and emergency fixture piping within the building shall be hard copper Type "L" seamless drawn tubing assembled with sweat fittings. All solder used shall be lead free, cadmium free, "Silverbrite - 100," or approved equal, complying with the latest issue of ANSI A-5.8 publication. All exposed runs to all toilet fixtures and sinks shall be chrome plated. As an alternate in the school building, the Plumbing Contractor can use polypropylene random copolymer (PP-RCT) for piping mains. This product shall not be used in the Storage/Toilet Building since it is unheated in the winter.

1. Mechanical grooved pipe couplings, fittings, Mechanical T's, and other products are acceptable to be used on piping systems and mechanical equipment connections 2" diameter and larger (in lieu of welded/flanged and threaded methods) in systems specified. Operating conditions not to exceed -30°F to 250°F temperature range according to the gasket lining selected and working pressures as shown in the coupling manufacturer's current product specifications.
   a. Copper Piping Systems: Grooved piping products for use with ASTM B88 hard Type L copper tubing shall be copper tubing sized. (Flaring of pipe ends to IPS dimensions is not allowed.) Fittings shall be ASTM B75 or B152 wrought copper or ASTM B584-87 bronze sand casting. Couplings shall be ASTM A395 and A536 ductile iron, with angle pattern bolt pads or tongue and groove design for rigidity upon visual confirmation of metal-to-metal bolt pad contact with no torque requirement. Coupling housings coated with copper colored alkyd enamel. Gaskets shall be Style "EHP" EPDM grade to suit the intended service. Gaskets used on potable water systems shall be EPDM, UL classified in accordance with ANSI / NSF61 for both hot (180F) and cold (86F) potable water service.

2. Press Fitting: Copper press fittings shall conform to the material and sizing requirements of ASME B16.18 or ASME B16.22. O-Rings for copper press fittings shall be EPDM.
   a. Manufacturers of Copper Press Fittings:
      Viega, 17545 Daleview Dr., Lakewood, OH 44107, (877) 620-0016;
      Rigid Tool Company, 400 Clark Street, Elyria, OH 44035, (800) 519-3456;
      Elkhart Products Corporation "Xpress Press-Connect Fittings", 1255 Oak Street, Elkhart, Indiana 46515, (800) 284-4851
      Nibco Press System, 1516 Middlebury Street, Elkhart, IN 46516-4740, (800)234-0227

3. Vic-Press 304™ Fittings: In lieu of alternate piping methods, Vic-Press 304™ may be used on piping systems 1/2" through 2” in size. Pipe shall be ASTM A312 Schedule 10 type 304/304L stainless steel. Fittings and couplings shall be precision cold drawn austenitic stainless steel, complete with synthetic rubber O-ring. O-ring grade to suit the intended service. O-rings used on potable water systems shall be EPDM, UL classified in accordance with ANSI / NSF61 for potable water service.
   a) Manufacturers of Vic-Press 304™ Fittings: Victaulic Company of America

4. Solder Standard: Solder metal shall conform to the requirements of ASTM B32. Soldering fluxes shall conform to ASTM B813. Solder and fluxes used in drinking water systems shall have a maximum of 0.20-percent lead (Pb) content.

5. Polypropylene: Pipe and fittings shall be Aquatherm, Niron Clima by Nupi Americas or equal, manufactured from a PP-RCT resin meeting the short-term properties and long-term strength requirements of ASTM F2389. The piping shall be extruded with a middle layer that has glass fiber content to restrict thermal expansion.
   a. Fittings may be either socket fusion through nominal 5 inch, electrofusion through 8 inch or butt fusion style in nominal 2 inch through 24 inch.

D. Cold water pipe below ground: Type K soft copper tubing with flared fittings or polypropylene (PP-RCT).

E. Indirect waste piping less than 1-1/4” in size shall be Type “L” hard drawn copper tubing with wrought copper sweat fittings joined with approved 95/5 lead free tin antimony solder.

F. Indirect waste piping 1-1/4” and larger in size shall be Type DWV hard drawn seamless copper tubing with wrought copper drainage fittings joined with approved 95/5 lead free tin antimony solder.

G. All above grade natural gas piping inside the building shall be Schedule 40 black steel pipe with malleable pattern fittings, installed in strict compliance with the Massachusetts Fuel Gas Code, (248 CMR 5.00). All piping 2 in. and below shall be assembled with screwed malleable iron fittings; 2-1/2 in. and above shall be welded. Provide necessary ball type gas shut-off valves or square head cocks and drips as required. All joints shall be made up with "Rectoseal" and tested.

1. All welding shall be done in accordance with the welding procedures of the National Certified Pipe Welding Bureau, or any other approved procedure, conforming to the requirements of the ASA Code for Pressure Piping. No welder shall be employed on the work who has not been fully qualified under the above specified procedure and so certified as a member of the local chapter of the National Certified Pipe Welding Bureau or similar locally recognized testing authority.

2. All natural gas piping, including gas shut-off valves and final connections to science lab equipment, shall be the responsibility of the Plumbing Subcontractor.

3. The Plumbing Subcontractor shall apply for the new natural gas service and the Owner shall pay for all fees and charges required. On-site service entrance piping shall be by Eversource Gas Company, including all gas pressure regulators and gas meter.

4. The natural gas piping is all low pressure per Eversource Gas Company, therefore there is no opportunity for elevated gas pressure into the building.

5. All gas piping and final connections to gas-fired boiler's gas trains and gas trains regulators vent piping shall be the responsibility of the Plumbing Subcontractor.

    a. All main gas pressure regulators shall be independently vented to a safe outdoor location. Vent lines from regulators shall not be connected into a common line with the bleed line from gas operated diaphragm valves or from pressure relief valves. Vent lines shall be of steel or wrought iron pipe with means provided at termination points to prevent stoppage of the lines by foreign material, water or insects. Coordinate with HVAC Subcontractor and Domestic Hot Water Boiler manufacturer for gas train venting requirements. These are not shown on the drawings, but are required to be installed by this contractor per code. Note that ventless gas regulators may be utilized on the gas trains.

6. Science room gas piping from outlet of emergency gas shut-off valves to gas turrets can be either as specified above or by using corrugated, semi-rigid stainless steel tubing with brass mechanical attachment fittings terminating in male pipe fittings as manufactured by TracPipe, Gastite, Titeflex Corporation, Metal-Fab Inc. or equal.

    b. Tubing is available is sizes 3/8", ½", 3/4", 1", 1-1/4", 1-1/2" and 2".
    c. The 3000 series stainless steel tubing is jacketed with yellow polyethylene sleeving which provides ease of running through joists, studs, and other building components. The jacket is marked at one foot intervals with the amount of tubing left on the reel, for quick measurement. The yellow color is the international designation for fuel gas.
    d. Straight male pipe fittings are standard and are available in sizes shown above to fit all tubing. Additional fittings include termination mount and flange-mount straight and 90° elbow fittings for termination of gas lines near movable appliances. Tee fittings are available for additional branch lines into tubing runs; reducer tees are available in popular sizes and pipe outlet tees terminate in pipe threads on the outlet leg for size changes utilizing available black iron reducer fittings.
    e. Accessories are available for expansion of the flexible piping material and additions to existing fuel gas piping systems. These accessories include: manifold-four port, pressure regulators, protection devices, and shut-off valves.

7. MegaPress Fittings: ½-inch through 4-inch shall conform to ASME B31.1, ASME B31.3, or ASME B31.9 MegaPress fittings with zinc and nickel coating for use with IPS carbon steel pipe conforming to ASTM A53, ASTM A106, ASTM A135, or ASTM A795. MegaPress fittings shall have an HNBR sealing element, 420 stainless steel grip ring, separator ring, and an un-pressed fitting leak identification feature. Sealing elements shall be verified for the intended use.

    a. Alternate product is Apollo POWERPRESS for pipe sizes ½" through 2" with the following features:

        ii. Leak Before Press® – un-pressed fittings will visibly leak during low pressure testing.
        iii. Visual Inspection Ring (VIR)
            1. Patented.
            2. Tabs that "break-away" when pressed.
            3. Color coded for easy identification of sealing element type.
            4. Acts as a "pipe guide", optimally positioning the inserted pipe, significantly reducing pipe deflection for a clean and straight connection.
            5. Protects O-Ring from debris or paint.
        iv. Increased cup depths – better seat, tighter seal, straighter runs.

v. Color coded protective shipping cap: Protects VIR and fitting/valve ends during shipping.
vi. Ridgid® XL & Milwaukee Press tool compatibility.
vii. Carbon steel press ball valve.
1. First and only in the market.
2. No need for adapters – Materials & cost savings, shorter laying lengths, reduced likelihood of potential leak paths

I. Compressed air piping – above grade: type 'L', hard drawn copper with silver brazed copper fittings. Provide brazed to thread fittings for connection of gas (air) turrets. Alternate piping material is aluminum pipe with push-to-connect joints.

J. Perforated PVC Piping for Radon Mitigation System shall be Schedule 40 PVC conforming to ASTM D-1785. Piping shall be manufactured from a PVC compound with a cell class 12454-B as defined in ASTM D-1784. Perforations shall consist of 2 rows of ½" holes positioned 120° radially on the pipe. Spacing between holes shall be 5". In addition to factory perforations, piping shall have 5/8" holes drilled between the two rows at 4 feet on center facing down for condensate drainage.

K. PVC Piping for Radon Mitigation System Above Grade shall be Schedule 40 PVC conforming to ASTM D-1785. Piping shall be manufactured from a PVC compound with a cell class 12454-B as defined in ASTM D-1784.

L. Stainless Steel Piping for Radon Mitigation System Outside shall be similar to Blucher-Josam Stainless Steel Drainage Waste Systems or approved equal. Stainless steel shall be high grade austenitic type/grade 304

M. Acid Resistant Pipe and Fittings:

1. The corrosive waste drainage system, conforming to ASTM F1412, shall be Orion Blueline flame-retardant polypropylene type II copolymer pipe and fittings. The pipe and fittings shall be joined using the Orion mechanical joint coupling. The pipe shall be supplied in factory grooved 10-ft length. Fittings are to meet or exceed Schedule 40 dimensions. Each Orion coupling shall have 300 series stainless steel outer band and 5/16" bolts, nuts and washers plated to meet a 100-hour salt spray test per ASTM B117. The polypropylene material shall conform to ASTM D4101.

2. As an alternate joining method, the Plumbing Subcontractor may consider using a socket fusion system as follows: The corrosive waste drainage system, conforming to ASTM F1412, shall be Orion's Blueline flame retardant pipe and fittings. Pipe and fittings shall be joined using the Orion socket fusion system conforming to ASTM D2657. The pipe shall be supplied in 10-ft lengths. The fittings shall meet or exceed Schedule 40 dimensions. The polypropylene material shall conform to ASTM D4101.

3. Piping shall be supported from clevis or loop type pipe hangers, to allow free movement of pipe for expansion and contraction, not greater than 4 ft. on centers.

4. Fixture traps shall be type UTP, P-trap with full drop union. Below ground traps shall be type RBP P-trap.

5. All floor drains serving the Science Labs are located under emergency showers/eyewash stations and/or under ice makers. The discharge from these floor drains is shown piped to the acid waste system. Therefore, acid resistant floor drains are required at these fixtures.

6. Orion corrosion resistant finished floor cleanouts shall be Type FCO, round or square as required for finish floor. Floor cleanouts shall be manufactured from fire retardant polypropylene material conforming to ASTM D 4101, ferrule supplied with countersunk plug and adjustable top with round or square nickel bronze cover, with AWCO (Acid Waste Cleanout) cast in cover.

    a. Alternate floor cleanouts: Zurn model #Z9A-CO1-F Adjustable Floor Cleanout – Polypropylene body with gas and watertight tapered plug and round scoriated stainless steel top with “AWCO” cast on cover, 3” or 4” as shown.

7. Acid resistant piping passing through fire walls shall have approved sleeves and fire stops.

8. Below ground piping shall be Schedule 40 polypropylene with heat fusion joints or electro-fusion Rionfuse® joists are also acceptable. Installation of above materials shall be in strict compliance with the State Plumbing Code and with manufacturer's installation recommendations and procedures.

9. Acid resisting piping and fittings shall be by Zurn ZPPG, Orion Fittings, Inc., Enfield Co., R&G Sloane Mfg. Co. (George Fischer), Fuseal, or approved equal acid drainage waste systems.

10. Pipe Supports: All piping installed under this Section of the Specifications shall be independently supported from the building structure and not from the piping, ductwork, or conduit of other trades. All supplementary steel required to meet the requirements specified herein shall be furnished and installed by the Plumbing Subcontractor and shall be subject to the approval of the Architect-Engineer.

11. An alternate Corrosive Waste Drainage System by Zurn Industries Inc. to be considered shall be as follows:

    a. Pipe shall be manufactured to Schedule 40 polypropylene pipe dimensions and tolerances per ASTM F-1412. Pipe to be supplied in 10 foot lengths and manufactured with a chemically resistant and fire retardant polypropylene material conforming to ASTM-D4101.

    b. Fittings shall be manufactured to Schedule 40 polypropylene pipe dimensions of a chemically resistance and fire retardant polypropylene material conforming to ASTM-D4101. Fittings to conform to applicable tolerances in ASTM-F1412.

    c. Pipe and fittings are joined by either heat fusion or by using mechanical joints. Zurn patented fittings accept either joining method.

        i) At Lab Benches: Pipe and fittings shall be joined by use of the Zurn mechanical seal that has a chemical resistance equal to the pipe and fittings. The mechanical joint system shall incorporate a positive mechanical system (groove) for axial restraint.

        ii) Above Grade: Pipe and fittings shall be joined by the use of the Zurn Fusion Lock™ joining machine. Each fitting socket shall have a molded Fusion Lock™ heavy gauge wire seal that can be rotated in the socket to desired position.

12. Another alternate Corrosive Waste Drainage System by Charlotte Pipe and Foundry Company to be considered shall be as follows:

    a. Special drainage systems for corrosive or acid waste shall be manufactured from CPVC Type IV, Grade I compounds with a minimum cell classification of 23447. Pipe and Fittings shall conform to ASTM F 2618. Pipe shall be Schedule 40 dimensions. One-Step Solvent Cement shall be specially formulated for chemical waste applications and conform to ASTM F 493. All pipe, fittings and cement shall be supplied as a system by a single manufacturer and shall be certified by NSF International for use in corrosive waste drain systems and shall bear the mark "NSF-cw". Special Drain system is to be the ChemDrain® system as manufactured by Charlotte Pipe and Foundry Co. Installation to be in accordance with manufacturer's instructions and all applicable code requirements. Buried pipe shall be installed in accordance with ASTM D 2321 and ASTM F 1668. The special drainage system is intended for the listed chemicals for use in non-pressure chemical waste applications with a maximum working temperature of 220° F.

N. pH Neutralization System: Refer to Section 2.42 for system description and component specifications. There is an alternate system specified in Section 2.49 as well.

2.7 VALVES AND SPECIALTIES

A. All valves in contact with potable water systems must be lead-free or meet the requirements of NSF61G. The model numbers given may not indicate this, but any submitted valve will be reviewed based on meeting the Lead Free law and NSF 61G.

B. Gate Valves:

1. Where indicated on the Drawings, all gate valves 4in. and larger shall be Class 125 iron body, bronze mounted and bonnet conforming to ASTM A 126, Class B cast-iron, flanged ends, with Teflon packing, two-piece packing gland assembly, Stockham Figure G-612, or approved equal.

2. Valves 3 in. and smaller, where indicated on the Drawings, shall be Class 125, body and bonnets shall be of ASTM B 62 cast bronze composition, solid disc, copper-silicon alloy stem, brass packing gland, Teflon packing, and malleable handwheel, solder end, Stockham Figure B-110, or approved equal.

3. Valves shall be as manufactured by Stockham, Jenkins, Hammond, or approved equal.

C. Butterfly Valves:

1. On grooved installations, shutoff valves may be Victaulic butterfly valve model 608N, Anvil International n style 6721, or approved equal for sizes 2-1/2” through 6”. Valves shall be cast bronze body, grooved ends with Grade CHP flouroelastomer-coated ductile iron disc. Seat rated -30F to 250F and UL classified IAW ANSI/NSF 61 for both hot (180F) and cold (86F) potable water service.

D. Ball Valves:

1. On water lines inside the building, ball valves 3 in. and smaller shall be as manufactured by Nibco “Lead-Free Brass Ball Valves" model #T-FP-600A-LF-LL two-piece body, full port, blowout-proof stem, PTFE seats, stainless steel ball, locking lever handle, threaded end. For solder end valve, provide Nibco “Lead-Free Brass Ball Valves" model #S-FP-

600AD-LF with drain. Provide 1-1/4 in. extended stems for piping 1/2 in. to 1 in. size; 1-1/4 in. extended stems for piping 1-1/4 in. to 2-1/2 in. size. Valves shall be provided with stainless steel ball, reinforced Teflon seats and seals, bronze body, 400 PSI WOG, positive l00 percent shutoff. Ball valves shall be full port style and all shall be lead free.

2. Drain valves at all low points shall be "Apollo" 78-100 or 78-200 Series, 1/2 in. or 3/4 in. solder by 3/4 in. hose end with attached dust cover cap and chain.

3. Valves on gas lines shall be UL listed, 250 PSI natural gas rated, "Apollo" Model 80-100-YRPV Series with tee or lever handle, as approved by the National Fuel Gas Code. Where indicated on the Drawings, for Classroom zone shutoffs, ball valves shall be enclosed in a recessed valve box, as hereinafter specified.

4. Ball valves shall be of one (1) manufacturer, Conbraco Industries, Inc., "Apollo," Watts Regulator, Nibco/Scott, or approved equal.

E. Balancing Valves:

1. Where indicated on the Drawings, furnish and install Y-pattern multi-turn globe style valves. Bronze or metal copper alloy body, calibrated with differential pressure connection points. Digital hand-wheel with concealed memory stop to provide full valve closure and re-opening to set position.

2. Balancing valves shall be as manufactured by Victaulic, Nibco, Armstrong, Anvil International Gruvlok GBV, Kemper Water Controls or approved equal.

3. Alternate balancing valve: Furnish and install Flow Design Inc. ICSS Inline AutoFlow Controller for drinking water applications featuring:

   a. Flow limiting cartridge is machined stainless steel for greater control accuracy and dependability. Factory adjustable.
   b. All wetted parts are stainless steel meeting NSF/ANSI Standard 372 for minimal lead content.
   c. Compact inline design is less than half the height of typical controllers, allowing the ICSS to fit easily into tight installation.
   d. Tested and approved for “commercial hot water applications”.

4. Alternate balancing valve: Furnish and install Circuit Solver (¾” – 2”), size as indicated on plans. Valve shall be Circuit Solver as manufactured by Therm-Omega-Tech, Inc or equivalent.

   1. Circuit Solver shall regulate the flow of recirculated domestic hot water based on water temperature entering valve, regardless of system operating pressure.
   2. When fully closed Circuit Solver shall bypass a minimum flow of hot water to maintain dynamic control of the recirculating loop.
   3. Circuit Solver valve is factory set for project conditions.
   4. Circuit Solver body shall be constructed of stainless steel. Internal components type 303 stainless steel; rated for 200 PSIG working pressure and 300˚F working temperature, NSF-61 Certified and the Thermal Actuator shall be spring loaded and self-cleaning.
   e. Circuit Solver to be installed by qualified tradesmen. Installed in each domestic hot water return piping branch beyond last hot water device in that (individual) branch. Provide suitable line size isolation valves, unions and strainer as indicated in piping

detail shown on drawings. Provide suitable access panel as required in non-accessible ceiling and wall installations.

f. Contact factory representative, Urell Incorporated at 617-923-9500 if additional information is required.

F. Check Valves:

1. Check valves shall be furnished and installed where indicated on the Drawings. Checks up to 3 in. shall be Class 125, solder ends, body and caps shall be ASTM B 62 cast bronze composition, swing type disc, Stockham Figure B-309.

2. Check valves 4 in. and larger shall be iron body, bronze mounted with body and cap conforming to ASTM A 126 Class B cast-iron, flanged, swing type disc, Stockham Figure G-931.

3. Check valves shall be as manufactured by Stockham, Jenkins, Milwaukee, or approved equal. All check valves shall be lead free.

G. Pressure Reducing Valves:

1. Provide adjustable pressure reducing valves manifold set to maintain a maximum water pressure of 70 psig (80 psig is maximum pressure allowed by code). Valve shall be cast iron body with bronze trim, flange connections, compression diaphragm, and stainless steel springs. Downstream pressure shall not vary more than one pound for every ten pounds of variation in incoming water supply pressure.

2. Install shutoff valve on each side of reducing valve. Install strainer on inlet side of pressure reducing valve. Install pressure gauge on inlet and outlet of valve.

3. Furnish and install, where indicated on the Drawings, Ametek/U.S. Gauge Co.'s Figure P500, 2 in. diameter, 0 lb. to 120 lbs. pressure gauges, complete with petcocks and brass connections.

4. On main water service entrance, a pressure reducing valve station is required as the static water pressure in the street is over 80 PSI. The pressure reducing valves shall be as follows:

a. For the primary water supply to the building, furnish and install a Watts Automatic Control Valve model #LFF6115-74JM (Globe) Pressure Reducing Control Valve with Low Flow By-Pass featuring the following:
   i. Throttles to reduce high upstream pressure to constant lower downstream pressure.
   ii. Low Flow By-Pass controls at low flows.
   iii. Main Line valve controls at high flows.
   iv. Reducing and Low Flow By-Pass setpoints are separately adjustable.
   v. 4” Reduced Port ANSI 150# Flanged.
   vi. Operation: The Pressure Reducing Automatic Control Valve with Low Flow By-Pass is designed to automatically reduce a fluctuating higher upstream pressure to a constant lower downstream pressure regardless of varying flow rates. It is controlled by a normally open, pressure reducing pilot designed to: 1) Open (allowing fluid out of the main valve cover chamber) when downstream pressure is below the adjustable setpoint, and 2) Close (allowing fluid to fill the main valve cover chamber) when downstream pressure is above the adjustable setpoint. A decrease in downstream pressure causes the valve to modulate toward an open

position, raising downstream pressure. An increase in downstream pressure causes the valve to modulate toward a closed position, lowering downstream pressure. A Low Flow By-Pass Valve is piped parallel to the Main Pressure Reducing Valve and is set approximately 10 PSI higher. The Low Flow By-Pass handles flow requirements below the range of the Main Pressure Reducing Valve. During “off peak” demand conditions, the Low Flow By-Pass provides flow and pressure to the downstream zone. As flow requirements increase beyond the capacity of the Low Flow By-Pass, downstream pressure falls below the setpoint of the Main Pressure Reducing Valve allowing it to throttle toward open, supplementing flow and pressure. As flow requirements decrease, downstream pressure rises above the setpoint of the Main Pressure Reducing Valve, causing it to throttle toward closed, allowing the Low Flow By-Pass to resume command of flow and pressure.

b. For the emergency bypass for the water supply, furnish and install a Watts #LF223-HP 2” High Capacity Water Pressure Reducing Valve as follows: A lead free water pressure reducing valve shall be installed on the water service pipe near its entrance to the building where supply main pressure exceeds 80 PSI to reduce it to 70 PSI or lower. The water pressure reducing valve shall be constructed using Lead Free material. Lead Free regulators shall comply with state codes and standards, where applicable, requiring reduced lead content. Provisions shall be made to permit the bypass flow of water back through the valve into the main when pressure, due to thermal expansion on the outlet side of the valve, exceed the pressure in the main supply. Pressure reducing valves with built-in bypass check valves and strainer will be acceptable. Approved valves shall comply with ASSE 1003.

5. Pressure reducing valves shall be as manufactured by Watts Regulator Co., Wilkins, A.W. Cash Valve Mfg. Co., Mueller Co., or approved equal.

H. Plug Valves: Furnish and install cast-iron plug valves on all natural gas piping 2 in. and larger, with flanged ends, Model 133 as manufactured by Serek Audco, with 100 percent free area, rated at 125 PSI working pressure, or approved equal.

I. Strainers: Strainers shall be iron body ‘Y’ type with bronze strainers, 250 psig steam and 400 W.O.G. Provide ball valve with hose bib for blow down similar to Watts # B-6000-CC.

J. Expansion Tanks: Expansion tanks shall be Taco #PAX series for domestic hot water application. The domestic hot water system expansion tanks shall be sized by the Plumbing Subcontractor/Manufacturer for review by the Architect/Engineer. The expansion tank, although precharged to 40 PSI, should be recharged to the CW inlet water pressure to the domestic hot water system or just under it. Verify expansion tank size with manufacturer before releasing (i.e. have the manufacturer run an expansion tank sizing program).Note: expansion tank size on the drawings was engineered and is sized as required. Also note that there are two (3) water heater/boiler systems that require expansion tanks.

1. Expansion tank shall be as manufactured by Taco, Watts Water Technologies, Flexcon Industries or approved equal.

K. Backwater Valve: coated cast iron backwater valve, offset type, bronze fixed swing-check assembly, bolted gasketed cover and no-hub connection similar to Josam model #67402, Jay R. Smith, Mifab, Zurn, Wade or equal. Furnish as shown on drawings as follows:

1. For HVAC condensate drains throughout the building.
2. For the storm drain system serving different roof elevations if the piping connects above grade. See plans.

3. A backwater valve is shown at the outlet of the pH neutralizing tank within the equipment pit.

L. Pipe Alignment Guides: Pipe alignment guides shall be concentric type Keflex Series P, or approved equal by Metraflex or Asco.

O. Ice Maker Supply, IMB: Furnish and install Sioux Chief model #.696-VC2 Ox Box Ice Maker outlet box recessed into the wall. Provide ½" supply line inlet connection (sweat) with 3/8" compression cold outlet. The valve shall be equipped with quarter-turn operation, chrome plated valve. If necessary, provide water hammer arrestor in box. Alternate manufacturers are Oatey and Viega. Note: These are shown for ice maker connections and refrigerator ice maker connections, but not for all refrigerators.

P. Venturi Fittings – Furnish and install Kemper Water Control Systems model #KHS Flow-Splitter Unit – dynamic, FTP, figure 651 06, or approved equal, with the following features:

1. To avoid stagnation in cold water (PWC) and hot water (PWH) pipework.
2. KHS Flow-Splitter - dynamic, according to the Venturi principle, including dynamic cartridge, flow and return branch for connection of outlets / plumbing units.
3. Wetted metal parts made from dezincification-free, corrosion-resistant and lead-free gunmetal, resistant against aggressive water.
4. KHS Flow-Splitter pass with female thread.
5. Plumbing unit feed pipe with female thread.
6. Plumbing unit return pipe with female thread.
7. Maintenance free.
8. Free from dead spots.
9. Include KHS stop valve, female threaded, figure 389 00.
10. Maintenance-free EPDM spindle seal.
11. Removable inner top part TOP-ENTRY, with EPDM gasket body and gunmetal ball.
12. Includes insulation shell.

Alternate product manufacturers are Taco Copper Monoflo Tees, B&G Monoflo Tees or Nibco Venturi Insert.

Q. Monoflo Fittings (Alternate to Venturi Fittings): B&G Monoflo Fittings make possible the use of a single pipe to act as both supply and return main for tempered water to emergency fixtures. These Fittings connect the risers to the main and assure proper diversion of water into each leg regarding of its position in the system.

R. Gas Fire Valve: Furnish and install natural gas fire valve on the 6" gas main into the building after rising from the gas header after the gas meter as manufactured by Preferred Utilities Manufacturing Corp., Inner-Tite Corp. or approved equal. Valve shall be flanged cast-iron with bronze disc and seat, stainless steel fuse assembly. Coordinate exact installation location with Eversource Gas Company.

S. Wall Mounted Water Hose Reel in CCL Lab: Furnish and install Controlled Return and Enclosed Water Hose Reel similar to Reelcraft model #RS7850 OLP, Premium Duty Spring Retractable Hose Reel or approved equal by T&S Brass or Coxreels. It shall have the following features:

1. Retracts at 2 miles per hour.
2. Integral clutch creates a consistent retraction speed regardless of fluid or environment temperatures.
3. Safely protects personnel and equipment.

4. Hose and bumper included, ½" I.D., 50 feet long, 300 PSI maximum pressure, 3/8" NPT(M) hose outlet, ½" NPT(F) reel inlet and outlet, 150°F maximum temperature.

2.8 BACKFLOW PREVENTERS

A. Furnish and install the following backflow preventers, reduced pressure or double check valve assemblies as manufactured by Watts Regulator, Apollo or Wilkins.

1. A Reduced Pressure Zone Assembly shall be installed at each potential health hazard location to prevent backflow due to back-siphonage and/or backpressure. The assembly shall consist of an internal pressure differential relief valve located in a zone between two positive seating check modules with captured springs and silicone seat discs. Seats and seat discs shall be replaceable in both check modules and the relief valve. There shall be no threads or screws in the waterway exposed to line fluids. Service of all internal components shall be through a single access cover secured with stainless steel bolts. Body and shutoffs shall be constructed using Lead Free* cast copper silicon alloy materials. Lead Free* reduced pressure zone assembly shall comply with state codes and standards, where applicable, requiring reduced lead content. The assembly shall also include two resilient seated isolation valves, four resilient seated test cocks and an air gap drain fitting. The assembly shall meet the requirements of: USC; ASSE Std. 1013; AWWA Std. C511; CSA B64.4. Shall be a Watts Series LF009.

2. Alternate MFR specification: The Apollo® Model RP4A and RPLF4A Lead Free* Reduced Pressure Backflow Preventer A Series provide maximum protection of the potable water supply due to back-siphonage or backpressure from substances that are hazardous to the potable water supply. The top accessed modular check valve cartridges provide captured springs, replaceable seats, and reversible silicone seat discs. This Made in America assembly features ball valve shutoffs with stainless steel handles and nuts as standard and carries the five-year Apollo® factory warranty.

B. Backflow preventers shall be installed at the following locations:

1. On cold water feed to hot water/chilled water hydronic system: No. LF909QT-SHW 1 in. complete with bronze strainer; quarter-turn, full port resilient sealed bronze ball valve shut-offs; bronze body construction; ball valve test cocks; captured spring assemblies; modular design; replaceable seats; stainless steel check modules for hot water temperatures (up to 210°F); and drain piping with air gap to receptor.

2. Furnish and install 6 in. Reduced Pressure Principle Backflow Preventer, Apollo® Model #RPLF 4A Lead Free* at the domestic water service entrance. In addition, furnish and install a second 6" bypass backflow preventer similar to above. The assembly shall be manufactured in America and carry a 5-year Apollo® factory warranty. The TriForceTM center-stem guided check valves shall feature reversible silicone rubber seat discs. The check valves shall be held in place by SS snap-in retainers. Access to the check valves and relief valve internals shall be by an Apollo® quick-connect SS coupling. The bodies shall be domestic SS in 4" size. The Lead Free* Apollo® domestic ball valve test cocks shall have SS handles. The assembly shall prevent contamination of the potable water supply due to back-siphonage or backpressure from substances that are health or non-health hazards. The pressure drop across the assembly shall be documented by an independent laboratory. There shall be two 6" backflow preventers installed.

3. For site irrigation system in the main school, furnish and install a backflow preventer on the cold water supply as follows:

a. Cold Water – 2” Model LF009QTS, Apollo model #4ALF200, or approved equal.

4. For boiler and chiller make-up water in Mechanical Room C115: Furnish and install backflow preventer on the cold water supply as follows:

   a. Cold Water – 1-1/4” Model LF009QTS, Apollo model #4ALF200, or approved equal.

5. For Upper Grade Science Rooms: Furnish and install backflow preventer on the domestic water piping as follows:

   a. Cold Water – 3” Model LF909QTS, Apollo model #4ALF200, or approved equal.

   b. Hot Water – 1-1/2” Watts Model #LF009-QTS, Apollo model #4ALF200, or approved equal. Hot water temperature is ~120°F.

6. For 9th Grade Science Rooms: Furnish and install backflow preventer on the domestic water piping as follows:

   a. Cold Water – 2” Model LF909QTS

   b. Hot Water – 1-1/4” Watts Model #LF009-QTS, Apollo model #4ALF200, or approved equal. Hot water temperature is ~120°F.

7. For dish-machine and 3-bay sink in kitchen: Furnish and install backflow preventer on the cold and hot water piping serving the fixtures similar to:

   a. Cold Water – 1” Watts Model #LF009-QTS, Apollo model #4ALF200, or approved equal.

   b. Hot Water – 1” Watts Model #LF009-QTS, Apollo model #4ALF200, or approved equal. Hot water temperature is ~120°F.

8. For trough drain cooling water connections in kitchen: Furnish and install backflow preventer on the cold water piping serving that runs below grade to the trough drains similar to:

   a. Cold Water – 1” Watts Model #LF009-QTS, Apollo model #4ALF200, or approved equal.

9. For Outdoor Toilet & Storage Building, Furnish and install backflow preventer on the cold water feed to the site drinking water stations around the field to the unit similar to:

   a. Cold Water – 1-1/2” Watts Model #LF009-QTS, Apollo model #4ALF200, or approved equal.

10. For Outdoor Toilet & Storage Building, Furnish and install backflow preventer on the cold water service entrance similar to:

    a. Cold Water – 3” Watts Model #LF009-QTS, Apollo model #4ALF200, or approved equal.

C. This Subcontractor shall provide a spare parts repair kit for each 009 or 909 reduced pressure backflow preventer, to consist of a repair kit for the first check, second check, and relief valve.

D. Units shall be Watts Regulator Co., Apollo, Wilkins, Febco, Division of CMB, Inc., Hersey Products, Inc., Conbraco or approved equal.

E. The Plumbing Subcontractor shall file and prepare all Applications for Backflow Preventers Testing approval with the Department of Environmental Protection 310 CMR 22.22 and pay all fees and charges.

F. All backflow preventers shall be installed and tested in accordance with Regulation 310 CMR 22.22. All design data sheets and plans for the installation of backflow prevention devices shall be reviewed by a certified cross connection surveyor, in this case, the City of Worcester DPW Water Division.

G. All certificates of approval and test results shall be sent to the Architect-Engineer.

2.9 TRAPS

A. Provide separate traps with integral cleanouts on fixtures and equipment requiring connections to sanitary system. Exceptions are fixtures with integral traps. Traps exposed to view, including connecting drain lines, shall be chrome plated. No trap shall be less than 1-1/2 inch and shall be sized as required by Code. The minimum trap size for below grade applications is 2”.

B. Traps shall be service weight cast-iron where buried in floors or serving floor drains with trap primer connections where noted on the Drawings. Where traps are not connected directly under the drain they serve in the floor, they shall be fitted with top cleanouts and extensions to the floor with access covers and plates.

C. Furnish and install traps as required for all items of equipment furnished under other Sections of these Specifications, and/or by the Owner.

2.10 INSULATION

A. All hot water, hot water recirculating, and cold water piping shall be insulated with Manville FLAME-SAFE fiberglass pipe insulation, Owens-Corning Fiberglass 25, Knauf or approved equal. The insulation shall have an average thermal conductivity not to exceed .25 BTU in. per sq. ft. per F. per hour at a mean temperature of 75 degrees F. Thickness of the insulation shall be 1/2 in. for cold water piping up to and including 2 in., 1 in. thick for cold water piping 2-1/2 in. and above, and 1 in. for hot water and hot water recirculating piping. Jacket shall be FLAME-SAFE AP. The insulation shall be applied over clean dry pipe with all joints butted firmly together. Longitudinal jacket laps and the butt strips shall be smoothly secured with Benjamin Foster 85-20 adhesive. Lab cold water shall be insulated as indicated above. For lab hot water piping insulation thickness, refer to section 2.27.A.

B. All concealed and exposed roof drains and rainwater leaders/storm drain and emergency overflow storm drain piping, verticals, mains, fittings, and offsets above ground shall be insulated with 1” thick insulation, same as specified for hot and cold water piping. Note that some emergency storm drain rain leaders are shown to not be insulated on the plans.

C. All fittings and valves shall be insulated with the proper factory pre-cut fiberglass insulation and covered using the factory, pre-molded, one-piece PVC fitting covers secured with flexible off-white 10 mil polyvinyl chloride film bonded with a specially formulated adhesive that can be installed indoors and out with a strong permanent bond conforming to MIL Spec. No. 7798-A.

D. All exposed supply and waste piping to handicapped lavatories or sinks shall be insulated with Truebro Model 101W or 102W "Handi-Lav-Guard" trap and hot water insulation kits with accessory no. 105. Equal manufacturers are McGuire Mfg. Co. Inc., Plumberex Specialty Products Pro-Extreme, or approved equal. Refer to paragraph 2.2.E for additional information.

E. All exposed insulated piping, in public areas, storage areas and garage, 10 ft. 0 in. up from finish floor shall be provided with an additional jacket made of high impact polyvinyl chloride 10 mil thickness, applied over herein before specified insulation, using vapor barrier mastic-adhesive.

F. All buried trap primer, hot and cold water piping shall be insulated with 1/2 in. foamed plastic insulation equal to K-Flex Insul-Tube® Flexible Closed Cell Pipe Insulation. Environmentally-friendly, CFC-free flexible elastomeric thermal insulation is non-porous, non-fibrous and resists mold growth. Used for reducing heat gain and preventing condensation or frost formation on cold water plumbing systems. EPA registered antimicrobial agent provides additional protection against mold, fungal and bacterial growth. Tough skin exterior withstands tearing and severe environmental conditions. UV resistant.

G. Tempered water piping for emergency showers and emergency eye/face washes shall not be insulated since the required water temperature will be between 65˚F & 75˚F.

H. Insulation shall be Manville, Owens-Corning, CertainTeed Corp., Armstrong, or approved equal.

2.11 PIPE SLEEVES, HANGERS AND SUPPORTS

A. Pipe sleeves, pipe hangers, pipe anchors, auxiliary steel, fire treated wood blocking and fixture supports shall be furnished and set by this Contractor, and he shall be responsible for the proper and permanent location. This Contractor shall be responsible for all core drilling.

B. Pipe sleeves shall be installed and properly secured at all points where pipes pass though masonry, concrete or wood. Pipe sleeves shall be of sufficient diameter to provide approximately ¼” clearance around insulation. Pipe sleeves through masonry partitions and floors shall be Schedule 40 galvanized steel pipe. Wall sleeves shall have chromium plated escutcheons with set screws or clips for firmly holding in place. Sleeves through wall shall end flush with surface of walls. Sleeves in floors shall extend 1” above the floor and after installation of piping shall be packed and made watertight. If installing pipe sleeves, do not cut the steel decking before the slab is poured. Provide core drilling after slab is poured and cured. Core openings shall have Link-Seal fire rated penetration closures. Note that the preferred sleeve option is through the use of Hilti “Platform for Metal Deck Firestop Sleeve” model #CFS-CID MD PLT, sized to fit piping. Sleeves in exterior walls shall have water stop plates, shall end flush with the surface of the walls and shall have Link-Seal penetration closures. Note that if coring, pipe sleeves are not required. Minimize the slab coring sizes wherever possible.

C. Where pipes penetrate fire rated floors and partitions, the openings shall be firestopped per Section 07 84 00 Firestopping, by the Plumbing Subcontractor. Note that cores of 4” diameter and below are by the Plumbing Subcontractor and cores over 4” diameter are by the General Contractor.

D. All piping shall be rigidly supported from the building structure by means of approved hangers and supports. This Contractor shall furnish and install all required auxiliary steel required for

hanging of piping. Per the Structural Engineer, piping over 4" in diameter must be supported from the building structural components and not the composite steel decking. The combination steel deck and concrete was not designed to support heavy piping 4" in diameter and above. The use of "Bang-It" Cast In-Place Concrete Insert Hangers may be acceptable for all plumbing piping 3" in diameter and less as long as bang-it spacing is defined per the structural engineer. Note that the slabs may be placed ahead of coordination, so there may not be time to install bang-its.

E. All horizontal piping shall be hung with approved adjustable malleable iron pipe hangers. Cast iron soil and storm drain piping shall be supported at 5' intervals except where 10' lengths of piping are used, then 10' intervals are acceptable. Supports shall be placed directly beneath horizontal fittings that connect to the stack. Copper tubing 1-1/2" and larger shall be supported at 10' intervals. Copper tubing 1-1/4" and smaller shall be supported at 6' intervals. Steel piping shall be supported at 6' intervals for piping 1/2" and smaller, at 8' intervals for ¾" and 1" piping and at 10' intervals for piping 1-1/4" and larger.

F. Vertical cast iron piping shall be supported at base, at each story height and at 10' intervals. Vertical steel piping and copper tubing shall be supported at each story height and at no more than 10' intervals.

G. Hangers for piping sizes 4" and smaller shall be Carpenter & Paterson, No. 1A band type, Anvil International, Grinnell Company, Calco Steel Products Company or equal, black steel with hanger rods with machine threads; for uninsulated copper tubing, the hangers shall be copper plated. Hangers for piping larger than 4" shall be the adjustable clevis hanger type, malleable iron and extension rod. Chain, strap, perforated bar or wire hangers will not be approved. Approved gang hangers may be used in lieu of separate hangers on pipes running parallel to each other and close together. Where used for uninsulated copper tubing, all hangers shall be copper plated. Insulation shields shall be provided on all horizontal insulated piping at each hanger or supported location. Insulation shields shall be galvanized steel, 180 degrees arc and centered in the hanger or support. On diameters 4" and smaller, shield shall be 12" long, 18 gauge steel. On diameters 5" and 6", shield shall be 18" long, 16 gauge steel. On diameters 8" and 10", shield shall be 24" long, 14 gauge steel. On diameters greater than 10", shield shall 24" long 12 gauge steel. This Contractor shall furnish and install steel insulation shields at each hanger location on piping to be installed. Structure attachments shall be as manufactured by Carpenter & Patterson, Anvil International, or approved equal and shall be suitable to carry the weight. Pipe alignment guides shall be split-sleeve type as manufactured by Broat Manufacturing, Inc. and suitable for copper tubing.

H. All fixtures and equipment shall be supported and fastened in a satisfactory manner and in accordance with fixture manufacturer's recommendations.

I. Where chair carriers are required, they shall be completely concealed in the building construction and shall rigidly support the fixture from the floor. Chair carrier shall support fixtures is such a manner that no part of the fixture will be supported by the wall or partition. Chair carriers shall be furnished complete with necessary bolt, nuts and washers as well as connecting nipples of the proper length with gaskets for the fixture connection. All available or optional anchor foot assemblies shall be utilized. Carriers must fit in available space and shall be of the special narrow type or compact style where necessary. Chair carriers for water closets and urinals shall include flushometer supply pipe support.

J. Wherever fire treated wood blocking is required to ensure adequate support of fixtures and related piping, it shall be provided by this Contractor.

K. At the roof level, all pipe hangers are to be hung from the structural steel framing, not from the metal roof deck.

L. At the floor levels, the following rules shall be followed per the Structural Engineer:

1. This trade contractor shall refer to “TYPICAL HANGER LOAD RESTRICTIONS at COMPOSITE SLABS and ROOF DECK” on drawing S1.03 for the following information:
   a. Hanger load limitations including associated pipe sizes.
   b. Metal roof deck notes.
2. This trade contractor shall design, furnish, and install all supplementary steel or Unistrut systems which shall be supported only by structural steel when hanger loads exceed limitations set forth in detail “TYPICAL HANGER LOAD RESTRICTIONS at COMPOSITE SLABS and ROOF DECK” on drawing S1.03.
3. “Sammy” hanger attachments are not permitted under any conditions.

M. All plumbing piping anchors shall be secured to structural steel framing, or supplemental steel directly attached to building structural steel, to insure a rigid connection. Anchor braces to top of steel beam where possible.

2.12 CLEANOUTS

A. Cleanouts shall be provided in soil and waste pipes and the radon system at changes in direction, where shown on Drawings, and at other points required by Code so that lines will be readily accessible for cleaning or rodding out; provide a minimum of 24 inch clearance for rodding. Cleanouts shall be same size as pipe in which they are installed but not larger than four inches.

B. Cleanouts shall be installed so that cleanout opens in direction of flow of drainage line served or at right angles thereto. Cleanout plug shall be kept free of dirt and construction materials and shall not be covered with cement, plaster or other permanent finishing materials.

C. Floor cleanouts shall have cast iron body and frame with square adjustable scoriated secured nickel bronze top. Unit shall be vertically adjustable for a minimum of two inches. When waterproofing membrane is used, provide clamping collar. Cleanouts shall consist of "Y" fittings and 1/8 inch bends with brass or bronze screw plugs. Cleanouts in tile floors shall have square top covers recessed for tile insertion; in carpeted areas, provide carpet cleanout markers. Floor cleanout shall be Zurn 1400 Series Level-trol Supreme cleanouts and Type ZN-1400-Z in terrazzo floors, Type ZN-1400-TX in tiled floors, Type ZN-1400-CM in carpeted floors, and Type ZN-1400 in all other locations. Cleanouts shall be set flush and level with top of finished floor surface except in carpeted areas where they shall be flush with concrete.

D. Provide cleanouts a base of vertical stacks with cleanout plug located approximately 30 inches above floor. Extend cleanouts to wall with access covers. Cleanout shall consist of sanitary tees. Furnish nickel-bronze square frame and cover with minimum opening 6 x 6 inches at each wall cleanout.

E. In horizontal runs above grade, cleanouts shall consist of cast brass screw plug in fitting or in caulked cast iron ferrule.

F. Wall cleanouts shall be brass, recessed head plugs with Zurn ZN1441 with round cover.

G. Provide floor and/or wall cleanouts of the type specified above; cleanouts shall be Zurn, Jay R. Smith, Josam, Mifab, Watts Drainage or equal.

2.13 ACCESS PANELS

A. Furnish access panels for access to all parts of the plumbing systems that require accessibility for the proper operation and maintenance of the system. Refer to specification section 08 31 00 for products. Access panels to be installed by building contractor depending on where it is to be installed (i.e. gypsum board, tiling, masonry, etc.). The access panels may be installed in non-rated and rated walls. Ensure that the access panel is rated based on the wall construction.

B. Size shall be sufficient for the purpose, but no less than 12 inches by 12 inches. Particular attention shall be exercised in the selection of doors for masonry walls in order that frame sizes used will match the courses of brick or block. In restrooms, the access panels are called out as 12”x12” stainless steel for accessing valves, trap primer valves and water hammer arrestors.

2.14 JOINTING COMPOUNDS

A. Provide pipe dope, Teflon tape, wax rings, neoprene gaskets and other jointing compounds as required by best standard practice and only on service as recommended by the manufacturer. Work shall conform to manufacturer’s recommendations with regard to use of putties, jointing compounds or both in installing plumbing fixtures and trim.

2.15 FLOOR DRAINS

A. Provide floor drains of the type specified hereinafter; drains shall be Zurn, Jay R. Smith, Josam, Mifab, Watts Drainage or equal. Provide suitable clamping device and extensions if required, where installed in connection with waterproofing membrane. Refer to plans for quantities of floor drains.

B. FD-1: Zurn ZB415-6B-P (Josam Model 3000*-A-2-50) round top or equal, coated cast iron floor drain, two-piece body with double drainage flange, invertable non-puncturing flashing collar, weepholes, 6” diameter polished bronze strainer head, (Nikaloy round SUPER-FLO grate), ½” trap primer connection, bottom outlet size varies (see plans); tile flange if required by floor type.

C. FD-2: Zurn ZN1901-K-3 (Josam Model 49024AS-4) or equal sanitary floor sink; square cast iron 8” deep with acid resisting interior, double drainage flange with weepholes, bottom outlet size varies, aluminum internal dome strainer, Nikaloy sanitary sloped rim, and Nikaloy anti-tilting (SUPER-FLO) 3/4 (three quarter) grate.

D. FD-3: Zurn ZB415-7B w/ZB329-9 (Josam Model 30004-7E3) round top or equal, cast iron floor drain, two-piece body with double drainage flange, invertable non-puncturing flashing collar, weepholes, adjustable polished bronze strainer head, 7” round grate with 9”x3-1/2” oval receptor funnel, 4” bottom outlet.(; tile flange if required by floor type.)

E. FD-4: Zurn model #Z507-P-Y 7” medium duty floor drain, round top, Dura-Coated cast iron body with bottom outlet, seepage pan and combination membrane flashing clamp and frame for medium-duty cast iron deep flange slotted grate, trap primer connection, sediment bucket.

F. FD-5: Zurn model #Z507-P 7” medium duty floor drain, round top, Dura-Coated cast iron body with bottom outlet, seepage pan and combination membrane flashing clamp and frame for medium-duty cast iron deep flange slotted grate, trap primer connection.

G. FD-6: Garage Trench Drain, 20'-0" long (QTY. = 3); Zurn model #Z886-HD-DGC: Channels are 80" long, 6-3/4" wide reveal and have a 4" throat. Modular channel sections are made of 0% water absorbent High Density Polyethylene (HDPE). Channels have a positive mechanical connection between channel sections that will not separate during the installation and mechanically lock into the concrete surround every 10". Channels weigh less than 2.31 lbs per linear foot, have a smooth, 1-1/2" radiused self-cleaning bottom with a Manning's coefficient of .009 and .75% or neutral 0% built in slope. Channels have rebar clips standard to secure trench in its final location. Channels provided with standard SBG grates that lock down to frame. Zurn 5-3/8" wide reveal Stainless Steel cast Bar Grate conforming to ASTM specification A351, Grade CF8 (type 304), cast grate is rated class E per the DIN EN1433 top load classification. Supplied in 20" nominal lengths with ½" wide slots, and ¾" bearing depth. Grate has an open area of 27.7 sq. in per ft. The .105" thick Heavy-Duty Stainless Steel Frame Assembly conforms to ASTM specification A-240 (type 304) with 10 – 4" long concrete anchors per 80". Grate lockdown bars are to be integral to the frame. All welds must be performed by a certified welder per ASTM standard AWS D1.6. Frames produced in the U.S.A.
Provide Zurn model #P6-DGC 20"x5-3/8" ductile iron slotted grate weighing 4.5 lbs per linear foot. The grate has an open area of 28.2 square inches per linear foot. Grate conforms to DIN rating of C, ANSI rating of Heavy-Duty, H-20 load rating and ASTM A536 Grade 80-55-06.

H. FD-7: Outdoor Storage Rm Trench Drain, 80" long (6'-8"L) (QTY. = 1); See specification for FD-6 trench drain and match.

2.16 SOLIDS INTERCEPTOR

A. Josam Series 61000 Nikaloy Solids Interceptor, bottom access, fixture trap type, with 1 ½" slip joint inlet, 1 ½" threaded side outlet, gasketed cover and removable perforated stainless steel basket. Equal manufacturers are Zurn model #Z1180, J.R. Smith Manufacturing Company, Rockford Sanitary Systems and Mifab. Note that top access solids interceptors are acceptable for floor mounted installations.

B. Locate as shown on drawings on Art Room/Maker Space Sinks for fixtures P15, P16 & P16A.

2.17 SEMI-AUTOMATIC GREASE INTERCEPTOR (GI-1)

A. Furnish and install GI-1 in kitchen serving various kitchen fixtures as required by code, similar to Schier Great Basin™ grease interceptor model # GB-250. It shall be lifetime guaranteed and made in USA of seamless, rotationally-molded polyethylene. Interceptor shall be furnished for above or below grade installation. Interceptor shall be certified to ASME A112.14.3 (type C) and CSA B481.1, with field adjustable riser system, built-in flow control, built-in test caps and three outlet options. Interceptor flow rate shall be 100 GPM. Interceptor grease capacity shall be 1,076 lbs. Cover shall provide water/gas-tight seal and have minimum 16,000 lbs. load capacity.

B. Provide interior grease interceptor of the type specified above; interceptor shall be Shier Great Basin, Zurn "Proceptor", Trapzilla, Rockford "R-Poly", Striem or Mifab "Big-Max".

2.18 WATER HAMMER ARRESTORS

A. Maintenance free water hammer arrestors shall be furnished and installed at all locations in the water systems where quick acting valves are installed as well as wherever water hammer may occur. Examples of such locations are as follows:

1. Flushometer valves.

2. Self-closing and metering faucets.
3. All laundry equipment.
4. Dishwashers or Glasswashers.
5. End of runs.

B. Water hammer arrestors shall be as manufactured by Zurn, Josam Manufacturing Company, J.R. Smith Manufacturing Company, Wade, Mifab Systems or Precision Plumbing Products, Inc. Type 304 stainless steel with nesting type bellows. Arrestors shall be installed at each and every multiple of fixtures or items as listed above, water hammer arrestors may serve groups of fixtures. Sizing and placement shall be in accordance with PDI Standard PDI-WH-201 and Certified to NSF 61G and/or California AB1953 lead-free standard. Provide access panels.

C. Water hammer arrestors shall be as follows (model numbers based on Zurn):

	Type	Fixture Unit Rating	Model
1.	SA “A”	1-11	Jay R. Smith 5005, PPP SC500A, Zurn Z1700-100
2.	SA “B”	12-32	Jay R. Smith 5010, PPP SC750B, Zurn Z1700-200
3.	SA “C”	33-60	Jay R. Smith 5020, PPP SC1000C, Zurn Z1700-300
4.	SA “D”	61-113	Jay R. Smith 5030, PPP SC1250D, Zurn Z1700-400

2.19 THERMOMETERS AND PRESSURE GUAGES

A. Straight Thermometers:

1. Where indicated on the Drawings, furnish and install 7 in. long die-cast aluminum case, "Adjustable Angle" red appearing mercury tubing thermometers, H.O. Trerice Co., Cat. A001 complete with separable stainless steel Type 304 socket, 30 degrees to 240 degrees F. range, and lagging extensions when installed in insulated pipe.

2. Thermometers to be adjusted to a position for maximum readability from normal operator's position.

3. Thermometers shall be H.O. Trerice Co., Weksler Instruments Corp., Weiss Instruments, or approved equal.

B. Dial Thermometers:

1. Dial thermometers, where indicated on the Drawings, shall be of the Bi-Metal actuated design with over-temperature and low temperature protection, with aluminum, hermetically sealed case, non-removable gasketed ring, 5 in. dished dial size, stainless steel stem with stainless steel thread connection, accuracy 1 percent at mid range, 2 percent at side ends, fixed 1/2 in. NPT with 3/4 in. NPT lead free or stainless steel well, dial shall have adjustability to be rotated 360 degrees and the stem turned 180 degrees for readability, range 0 degrees to 240 degrees F. and with 4 in. stem lengths.

2. All thermometers shall be installed at an angle easily readable from the floor. All thermometers shall have brass separable sockets with casings.

C. Pressure Gauges: Pressure gauges shall be as manufactured by Trerice, or approved equal, Series 600, 4-1/2 in. diameter, range 0 to 200 PSI, aluminum case, white face with black figures, with petcocks. Any component of the pressure gauge that comes in contact with potable water shall be lead free or stainless steel.

1. Pressure Gauges shall be H.O. Trerice Co., Weksler Instruments Corp., Weiss Instruments, or approved equal.

2.20 HOT WATER CIRCULATING PUMPS

A. Furnish and install all stainless steel construction circulation pumps, as follow:

1. Pump No. (RP-1 & RP-2) 120 degrees – Building HWR:

   Furnish and install, in Mechanical Room C115, where indicated on the Drawings, Taco model #1915e-SF ECM High-Efficiency Circulators, 20 - 650 Watts maximum, 1 phase, 115 volt motor with built-in overheat protection, to deliver 22.5 GPM at 30 ft. head.

2. Pump No. (RP-3 & RP-4) 70 degrees – Tempered Water Piping for Emergency Showers throughout building:

   Furnish and install, in Mechanical Room C115, where indicated on the Drawings, Taco model #0034e-SF2 ECM High-Efficiency Circulators, 10-170 Watts maximum, 1 phase, 115 volt motor with built-in overhead protection, to deliver 12.0 GPM at 20 ft. head.

- The above specified RP-1 & RP-2 pumps are the Taco model #1915e series. Any substitution shall be equivalent to this pump. The Taco pump is characterized by the following:

1. 65’ Shut-off head, 120 USGPM max flow.
2. ECM brushless DC, high-efficiency, soft start, high starting torque motor.
3. Easy to program pump interface.
4. Self-Sensing.
5. Multiple Operating Modes: 4 Constant Pressure, 3 Constant Speed, 1 Proportional Pressure.
6. LED Status Light.
7. Error Diagnostics: Locked Rotor, Overcurrent, Over & Under Voltage, Over Temperature, Communications Failure.
8. External Inputs/Outputs: 0-10 Vdc external speed control, remote enable, overload relay output, parallel pump control.
9. High quality mechanical seal: Carbon/Silicon-Carbon/Viton for SS model.

- The above specified RP-3 & RP-4 pumps are the Taco model #0034e series. Any substitution shall be equivalent to this pump. The Taco pump is characterized by the following:

1. Maximum operating pressure: 150 PSI.
2. Minimum NPSHR: 18 psi @ 203°F.
3. Maximum fluid temperature: 230°F.
4. Minimum fluid temperature: 14°F.
5. Electrical specifications: Voltage = 115V for this application. Maximum operating power: 170W and maximum amp rating: 1.48A.
6. Stainless steel model suitable for open loop potable water systems.
7. Taco circulators are for indoor use only.
8. 5 easy dial settings to match system requirements: activeADAPT™, Low, Medium, High or 0-10V DC analog or PWM digital signal external input.
9. BIO Barrier® protects the pump from system contaminants.
10. SureStart® automatic unblocking and air purging mode.
11. Multi-color LED: power on, mode setting and error code diagnostics.

12. Nut-grabber feature on flanges for easier fit-up.
13. Dual electrical knockouts and removable quick-connect terminal strip for easy wiring.
14. Double insulated.
15. Whisper quiet operation.
16. Rotatable control cover to simplify installation.

B. The pumps shall be controlled by immersion aquastats installed in 1-1/4 in. oversize tee and pipe, as detailed. Aquastat shall be provided and installed by the Plumbing Subcontractor and wired by the Electrical Subcontractor.

1. Circulator Aquastat shall be Honeywell model #L4006B1163 or approved equal, 100 - 240°F temperature range, 5 - 30°F adjustable temperature differential. Aquastat shall have totally enclosed Micro Switch & snap-acting switches that operate on temperature rise to setpoint, visible control point scale and external adjustment screw horizontal or vertical insertion of the sensing element, direct or well immersion of the sensing element.

C. Install one (1) Bell & Gossett model #E-902AAB in-line pumps for each boiler. These pumps are furnished with the boilers and are sized to deliver 112 GPM at 32 ft. head. The pumps are for the domestic hot water boilers, one per boiler, installed per manufacturer's instructions. These are 1 HP pumps with a rated voltage of 208V-3phase.

D. Circulating pump shall be Taco, Armstrong Pumps Inc., Bell and Gossett, Grundfos Pumps Corp., or approved equal.

E. Circulating pumps must be balanced to ensure proper flow. Pump performance should be documented at the close-out of the project.

2.21 THERMOSTATIC MIXING VALVE ASSEMBLIES

A. Furnish and install mixing valves where indicated or required as manufactured by Powers Controls. Acceptable mixing valves shall be manufactured by Powers, Leonard Valve Company, Symmons, Armstrong Rada, Lawler or approved equal and shall match the performance characteristics for each mixing valve.

B. MV-1: Furnish and install in the Mechanical Room one (1) Powers #LFIS100VL Lead-Free digital water temperature control and monitoring system shall feature 3.5" full-color touchscreen interface which is configurable on location and does not require factory pre-programming. System shall control water temperature to +/- 2°F in accordance with ASSE 1017 and resist "temperature creep" during periods of low/zero demand. Controller shall be password protected and feature a user-adjustable outlet temperature range of 60 - 180°F with high and low temperature alerts, and an approach temperature of 2°F.
System shall digitally control and monitor mixed outlet temperature. Controller shall integrate with building automation systems (separate module not required) through Bacnet and Modbus protocols and feature local and remote temperature alarms. System will feature a user-set, high-temperature sanitization mode for thermal disinfection of bacteria and a programmable temperature set back feature to improve energy efficiency. System will also feature high speed actuator with override feature. In the event of a power failure, system will open full cold supply. In case of a loss of cold water, the system will close hot water supply. System shall be listed/approved to ASSE 1017, cUPC, NSF , CSA 24/UL873 and BTL (Bacnet Testing Laboratories). The digital mixing valve shall be rated for a minimum 0.5 GPM flow, maximum 55 GPM at 10 PSIG pressure drop. The probable flow rate is 27.6 GPM. Set the discharge to 120°F.

C. MV-2: Furnish and install in the Mechanical Room for the Building Emergency Shower & Eye/Face Wash Units one (1) Powers ETV400ADPOOO emergency tempering master mixing valve. Cabinet supply fixture for supplying tepid water to emergency fixtures shall be factory assembled, tested and include a stainless steel cabinet. Thermostatic mixing valve must have internal cold-water bypass system to ensure flow in the event of valve failure or loss of hot water supply. Supply fixture also includes copper piping, ball valves and temperature/pressure gauge for diagnostics. The valve shall be listed to ASSE 1071 and IAPMO UPC, provide precise temperature control over a wide range of flow conditions, and effectively shut down on loss of cold water. The valve shall feature paraffin-based actuation technology and checkstops to prevent cross flow. The valve shall be factory set to 85°F with lockage means of securing the temperature. Capacity of 3-102 GPM at 45 psid. The tempering valve shall be rated for a minimum 3.0 GPM flow, maximum 48 GPM at 10 PSIG pressure drop. The probable flow rate is 40 GPM (i.e. two emergency showers operating). Set the discharge to 75°F.

D. For single-user wall hung lavatories or individual fixtures where noted and individual kitchen hand sinks not already receiving tempered water, provide point-of-use thermostatic mixing valve similar to Powers LFG480-11 3/8" hot water tempering mixing valve with adjustable temperature setting set for 110°F for each lavatory & sink. Maximum valve setting shall not exceed 112°F. Capacity of the valve must be 3 GPM @ 45psi differential or 4 GPM @ 45psi differential. Thermostatic lavatory tempering valve shall be constructed using Lead Free* brass material which shall comply with state codes and standards, where applicable requiring reduced lead content. Control temperature must be adjustable between 80 - 120° F with a locking nut to prevent unauthorized or accidental adjustment. The valve shall contain integral checks to prevent cross flow and inlet screens to filter debris.

2.22 AUTOMATIC TRAP PRIMER VALVE

A. Furnish and install automatic trap primers where indicated or required as manufactured by Precision Plumbing Products, Model P-1 or P-2, as noted on the Drawings, with vacuum breaker and adjustment set screw.

1. These are adjustable to the static line pressure by use of the adjusting screw. System operating range is 20 PSI minimum to 80 PSI maximum.
2. The valve requires a 10 PSI pressure drop across the valve to activate and will deliver a metered amount of water to the floor drain. The trap primer is to be connected to a cold water supply only.
3. Constructed of 360 brass, EPDM E70 O-rings, Dow #7 Silicone, #60 stainless steel mesh screen, stainless steel adjustment screw.
4. Model P1-500 will prime 1-4 floor drains using PPP model #DU-U Distribution Unit.
5. Model P2-500 will prime 1-2 floor drains using PPP model #DU-U Distribution Unit.

B. Provide distribution unit(s) as required to supply multiple floor drains as manufactured by Precision Plumbing Products.

C. Provide air gap fitting below the trap primer valve and before the distribution unit, similar to Precision Plumbing Products, Model #AG-500.

D. Provide automatic trap primer valves of the type specified above; trap primers shall be Precision Plumbing Products (PPP Inc.), Jay R. Smith, Mifab, Sioux Chief Mfg. Co. or approved equal.

2.23 FLOOR DRAIN TRAP GUARD INSERTS

A. An alternate method of protecting floor drain traps is allowed by the MA Plumbing Code and the MA Plumbing Board. If there are multiple floor drains in a space, one shall have an automatic trap primer valve installed and the rest can have a Trap Guard Insert to protect the p-trap from drying out. Please note that there are some areas in the school where Trap Guard Inserts are shown in addition to a trap primer. This is because there is likely no way to keep the p-trap from drying out due to limited drainage. The use of Trap Guard Insert is an attempt to prevent odors from occurring regularly. Coordinate with the Plumbing Inspector and G.C.

B. Product Description: An Elastomeric, Normally Closed Trap Guard Device utilizes a normally closed seal to prevent evaporation of the trap seal and also protect against sewer gases from backing up into habitable areas. It opens with fluid and allows liquid drainage to flow through into the building drain.

C. Installation Instructions: Product shall be installed in accordance with the manufacturer's instructions and the requirements of the applicable codes. Device can be installed inside other manufacturer's drain tail pieces or optionally inside 2", 3" or 4" pipe that connects the various types of floor or hub drains. If a T&P relief valve is discharged into the Trap Guard device, it must be discharged into the center opening of the device. A strainer with a center hole is available for that purpose.

D. Product Identification: The Trap Guard device package shall be legibly marked or labeled with the Trap Guard name, trademark and model number.

E. Maintenance Instructions: The device should be inspected periodically for build-up of any debris and be flushed out thoroughly with clear warm water.

F. Test Methods and Performance Requirements: The elastomeric membrane material shall be tested according to the CAN/CSA B602 standard requirements of sections 4.1.2, 4.1.3, 4.1.5, 4.1.6, 4.1.8, 4.1.10 & 4.1.11.

   1. Pressure testing shall be performed to determine the back pressure of the device to hold back compressed air from 5.2 PSF and then increased to 10.4 PSF with no leakage.

   2. Testing shall be performed to verify that a plumbing snake can be effectively used with the Trap Guard device installed. For a typical 4" diameter floor drain, a 1-1/2" PVC pipe shall be inserted the entire length of the device with lubrication to provide an adequate pathway for a plumbing snake.

   3. Testing shall be performed to determine the maximum water flow the device could accommodate using an electric sump pump and a portable water reservoir. The pump discharge shall be into the Trap Guard device installed into a simulated drain assembly. Test acceptance is 30 GPM.

G. Trap Guard Inserts shall be manufactured by ProVent Systems Inc., or approved equal by Josam, Zurn, Sioux Chief. They are design for 2", 3" and 4" floor drains or floor sinks.

2.24 MDC CATCH BASIN GASOLINE TRAP

A. Provide Commonwealth of Massachusetts Plumbing Board approved Gasoline, Oil and Sand Separator on garage waste system. Circular basin shall be three and one-half feet diameter (42") minimum, and the tank depth below the inlet pipe shall be 5'-10". Basin shall be solid concrete precast with water-tight connections with all concrete consisting of one-part

concrete and two-parts sand. Cement brick, hollow concrete, or cinder block masonry products shall not be used.

B. The separator is to be located inside of a building where possible and the cover is to incorporate a center-hole. A sealed tight cover is to be used since the separator is located inside of a building. The cover shall be no less than 24” diameter. The separator shall be located and constructed to prevent surface or sub-surface water from entering. The inlet pipe shall be no less than four inches above the water line level. When the separator is subject to freezing, it shall be set a minimum of three feet below grade. The separator shall be filled with water and leak tested before being introduced into service. The non-corrosive steps shall be spaced at 18” apart. The chamber vent and outlet vent shall run independently inside of the building and extend through the roof.

2.25 HOT WATER BOILER (BLR-1 & 2)

A. The domestic water boiler shall be a LOCHINVAR ARMOR Model AWN1250NPM having a modulating input rating of 1,250,000 BTU/HR, a recovery capacity of 1485 gallons per hour at a 100^{o}F rise and shall be operated on Natural Gas. The domestic water boiler shall be capable of full modulation firing down to 20% of rated input with a turn down ratio of 5:1.

B. The domestic water boiler shall bear the ASME "H" stamp and shall be National Board listed. There shall be no banding material, bolts, gaskets or "O" rings in the header configuration. The stainless steel combustion chamber shall be designed to drain condensation to the bottom of the heat exchanger assembly. A built-in trap shall allow condensation to drain from the heat exchanger assembly. The complete heat exchanger assembly shall carry a five (5) year limited warranty.

C. The domestic water boiler shall be ANSI Z21.10.3 certified. The domestic water boiler shall comply with the energy efficiency requirements of the latest edition of the ASHRAE 90.1 Standard. The domestic water boiler shall be AHRI certified to 98% thermal efficiency. The domestic water boiler shall be certified for indoor installation.

D. The domestic water boiler shall be constructed with a heavy gauge steel jacket assembly, primed and pre-painted on both sides. The combustion chamber shall be sealed and completely enclosed, independent of the outer jacket assembly, so that integrity of the outer jacket does not affect a proper seal. A burner/flame observation port shall be provided. The burner shall be a premix design and constructed of high temperature stainless steel with a woven metal fiber outer covering to provide modulating firing rates. The domestic water boiler shall be supplied with a gas valve designed with negative pressure regulation and be equipped with a variable speed blower system, to precisely control the fuel/air mixture to provide modulating domestic water boiler firing rates for maximum efficiency. The domestic water boiler shall operate in a safe condition at a derated output with gas supply pressures as low as 4 inches of water column.

E. The domestic water boiler shall utilize a 24 VAC control circuit and components. The control system shall have an electronic display for water heater set-up, water heater status, and water heater diagnostics. All components shall be easily accessed and serviceable from the front of the jacket. The domestic water boiler shall be equipped with; a high limit temperature control certified to UL353, ASME certified pressure relief valve, outlet water temperature sensor, inlet water temperature sensor, a UL 353 certified flue temperature sensor, low water flow protection, built-in freeze protection. The manufacturer shall verify proper operation of the burner, all controls and the heat exchanger by connection to water and venting for a factory fire test prior to shipping.

F. The domestic water boiler shall feature the “Smart System” control with a Multi-Colored Graphic LCD touch screen display, password security, pump delay with freeze protection, pump exercise, and USB PC port connection. The domestic water boiler shall feature night setback for the domestic hot water tank and shall be capable of controlling a building recirculation pump while utilizing the night setback schedule for the building recirculation pump. The domestic water boiler shall have the capability to accept a 0-10 VDC input connection for BMS control of modulation or setpoint and enable/disable of the water heater, and a 0-10 VDC output of water heater modulation rate. The domestic water boiler shall have a built-in cascading sequencer with modulation logic options of “lead lag” or “efficiency optimized”. The domestic water boiler R shall be capable of remote communication via optional CON-X-US™ Remote Connectivity which is capable of sending test message or email alerts to notify the caretaker of a boiler alarm and remote programming of onboard boiler control. Both modulation logic options should be capable of rotation while maintaining modulation of up to eight water heaters without utilization of an external controller. Supply voltage shall be 120 volt / 60 hertz / single phase.

G. The domestic water boiler shall be equipped with two terminal strips for electrical connection. A low voltage connection board with data points for safety and operating controls, i.e., Auxiliary Relay, Auxiliary Proving Switch, Alarm Contacts, Runtime Contacts, Manual Reset Low Water Cutoff, Flow Switches, High and Low Gas Pressure Switches, Tank Thermostat, Tank Sensor, Building Management System Signal, Modbus Control Contacts and Cascade Control Circuit. A high voltage terminal strip shall be provided for supply voltage. The high voltage terminal strip plus integral relays are provided for independent control of the Domestic Hot Water Pump and Building Recirculation Pump.

H. The domestic water boiler shall be installed and vented with a Vertical Vent and Sidewall Air system with a vertical roof top termination of the vent with the combustion air being drawn horizontally from a sidewall. The flue shall be Polypropylene or Stainless Steel sealed vent material terminating at the roof top with the manufacturers specified vent termination to comply with UL1738. A separate pipe shall supply combustion air directly to the domestic water boiler from the outside in a different pressure zone than that of the exhaust vent. The air inlet pipe may be PVC, CPVC, Polypropylene or Stainless Steel sealed pipe. The domestic water boilers total combined air intake length shall not exceed 150 equivalent feet. The domestic water boilers total combined exhaust venting length shall not exceed 100 equivalent feet. *Foam Core pipe is not an approved material for exhaust piping.*

I. The domestic water boiler shall have an independent laboratory rating for Oxides of Nitrogen (NO_x) of 20 ppm or less, corrected to 3% O_2.

J. The domestic water boiler shall operate at altitudes up to 4,500 feet above sea level without additional parts or adjustments.

K. The domestic water boilers firing control system shall be M9 Direct Spark Ignition with Electronic Supervision

L. The domestic water boiler shall be constructed in accordance with MA Massachusetts Code.

M. Domestic Boilers shall be Lockinvar, Heat Transfer Products, Burnham, Thermal Solutions, Laars Heating Systems Company or approved equal.

2.26 STORAGE TANK (HWS-1 & 2)

A. The storage tank shall be a Lochinvar Lock-Temp "Energy Saver" tank, Model RGA0650 with vertical construction having a storage capacity of 650 gallons. The tank shall be constructed with

an inner chamber baffle designed to receive all circulation to and from the water heater to eliminate turbulence in the tank. The baffled tank shall supply 80% of tank capacity without a drop in outlet temperature, regardless of rate of draw.

B. The storage tank shall be constructed in accordance with ASME Boiler and Pressure Vessel Code requirements, (if ASME – "HLW" stamped and registered with the National Board of Boiler and Pressure Vessel Inspectors). The tank shall be furnished with the following connections: two 3" NPT dielectric circulating connections, one 2" NPT dielectric hot water outlet, one 1-1/4" NPT relief valve connection, one 3/4" NPT aquastat opening and one 1" NPT drain connection.

C. The storage tank shall have a working pressure of 150 PSI. The interior of the storage tank shall be glass lined and fired to 1600° F to ensure a molecular fusing of glass and steel, furnished with magnesium anodes and carry a five (5) year limited warranty.

D. The storage tank shall be constructed with a heavy gauge galvanized steel jacket assembly, primed and pre-painted on both sides with a minimum dry film thickness of 0.70 mills. The storage tank shall be completely encased in a minimum of 2" thick, high density polyurethane foam insulation to meet the energy efficiency requirements of the latest edition of the ASHRAE 90.1 Standard.

E. Provide vacuum breaker and temperature/pressure relief valve conforming to Massachusetts Plumbing Code.

F. Provide a diaphragm type expansion tank rated for domestic water use and sized for the expansion volume and pressure of the hot water system. Also, provide a diaphragm type expansion tank for the boiler system.

G. Domestic Hot Water Storage Tanks shall be Lochinvar, Heat Transfer Products, Burnham, Thermal Solutions, Laars Heating Systems Company or approved equal.

2.27 ELECTRIC WATER HEATER – OUTDOOR RESTROOM & STORAGE BUILDING (OSEWH-1)

A. Water heater shall be model #ELD80-6, manufactured by RHEEM/RUUD, having electrical input of 6 kW and a recovery rate of 27 GPH at a 90°F temperature rise. Water heater shall have a storage capacity of 80 gallons. Water heater shall have the UL seal of certification and be factory equipped with an AGA/ASME rated temperature and pressure relief valve. Tank interior shall be coated with a high temperature porcelain enamel and furnished with an R-Tech resistored magnesium anode rod rigidly supported. Water heater shall meet of exceed the energy factor requirements of ASHRAE Standard 90.1b-1992. Tank shall have a working pressure rating of 150 psi, and shall be completely assembled. Water heater shall be equipped with copper, low watt density, resistored, "screw-in" type elements. Tank shall be insulated with 2-1/2" rigid polyurethane foam insulation. Water heater shall be equipped with surface mounted thermostats each with an integral, manual reset, high limit control. Water heater shall be covered by a three year limited warranty against tank leaks.

   i. Domestic Hot Water Storage Tanks shall be Rheem/Ruud, Lochinvar, Heat Transfer Products or A.O. Smith.

B. Provide automatic shutoff device for excessive tank temperature. Initial tank water temperature shall be set to 125°F.

C. Heaters shall be provided with a manufacturer's warranty of at least 3 years based on commercial use.

D. Provide vacuum breaker and temperature/pressure relief valve conforming to Massachusetts Plumbing Code.

E. Where a backflow has been installed on the main water service into the building and /or the service into the water heater, provide a diaphragm type expansion tank rated for domestic water use (potable systems) and sized for the expansion volume and pressure of the hot water system.

2.28 MINI-TANK ELECTRIC WATER HEATER – REMOTE SINKS (EWH-1)

A. Furnish and install, where shown on the drawings, mini-tank electric water heaters in the base cabinet serving the individual sink or multiple sinks. The water heater shall be Bosch, Stiebel Eltron, Ariston, EEMAX, HTP or approved equal.

B. The Bosch Tronic 3000T point-of-use electric mini-tanks are available in three sizes which can be wall-hung (bracket included) or floor-mounted. Simply tap into the cold water line and install the water heater directly at the sink to provide hot water. They may also be installed in-line with a larger hot water source to eliminate the wait for hot water. The water heater features are:

1. Supplies up to 2 sinks at a time (ES8 model)
2. Provides hot water quickly at point-of-use
3. Compact, lightweight, space saving
4. Units can be wall / floor mounted (bracket included) with multi-directional mounting available (ES8 model only)
5. Temperature / pressure relief valve included on ES8
6. Temperature / pressure relief valve installed on ES4 and ES2.5
7. Glass-lined tank for long service life
8. Models ES2.5 and ES4 have a simple 120VAC plug-in connection (1440 Watts)
9. Model ES8 has a hard wired connection (1440 Watts)

C. EWH-1: For single sinks, provide Bosch model #ES4 or approved equal by HTP “Everlast” model #EVR04.0A014C or EEMAX MinTank model #EMT4.

2.29 PIPE IDENTIFICATION AND VALVE TAGS

A. All piping, except that piping which is within inaccessible chases, shall be identified with semi-rigid plastic identification markers equal to Seton or approved equal Setmark pipe markers or Marking Services Inc. Direction of flow arrows are to be included on each marker. Each marker background shall be appropriately color coded with clearly printed legend to identify the contents of the pipe in conformance with the “Scheme for the Identification of Piping Systems” (ASME 13.1-2007). Setmark snap-around markers shall be used above six inch overall diameters up to six inches and strap-around markers shall be used above six inch overall diameters. Markers shall be located adjacent to each valve, at each branch, at each cap for future, at each riser take off, at each passage through wall, at each pipe passage through floors, at each pipe passage to underground and on vertical and horizontal piping at 20 foot intervals maximum. All non-portable water lines and outlets shall be identified in accordance with the requirements of the Massachusetts Uniform State Plumbing Code.

B. All valves shall be designated by distinguishing numbers and letters carefully coordinated with a valve chart. Valve tags shall be 19 gauge polished brass, 1-1/2 inch diameter with stamped black filled letters similar to Seton S type 250-BL or approved equal. Lettering shall be 1/4 inch high for type service and 1/2 inch for valve number. Tag shall be attached to valves with approved brass “S” hooks, or brass jack chin. Whenever a valve is above a hung

ceiling, the valve tag shall be located immediately above the hung ceiling. Check valves do not need to have an ID.

C. Furnish a minimum of two typed valve lists to be framed under glass or plexi-glass. Each chart shall be enclosed in an approved .015 inch thick plastic closure for permanent protection. Valve numbers shall correspond to those indicated on the Record Drawings and on the printed valves lists. The printed list shall include the valve number, location and purpose of each valve. It shall state other necessary information such as the required opening or closing of another valve is to be opened of closed. Printed framed valve lists shall be displayed in each Mechanical Room or in location designated by the Owner.

D. Equipment nameplates shall be 3/4 inch by 2-1/2 inch long .02 inch aluminum with a black enamel background with engraved natural aluminum letters similar to Seton Style 2065-20. Nameplate shall have pressure sensitive taped backing. Alternate MFR is Marking Services Inc. model MS-215.

E. Provide a brass will plaque, minimum .020 inch thickness, secured to the exterior wall just above the grade line for all buried serviced entrances or exits. Samples of such are: Water Service Below; Sanity Sewer Below; Kitchen Waste Below; Storm Drain Below; etc.

F. Label all flue and combustion air piping with stick-on labels (EXHAUST / INTAKE).

2.30 HOSE BIBBS, SILL COCKS AND ROOF HYDRANTS

A. Interior hose bibbs (H.B.'s) shall be Woodford Model B24, Josam, Zurn, Mifab, Wade, Prier or equal; chrome plated, anti-siphon, vacuum breaker protected wall faucet, hose connection, enclosed in a flush mounted wall box. Provide at each bathroom group and in Boiler Room. Note that for non-public areas, Woodford Model 24 exposed hose bib can be used.

B. Freeze-proof sill cocks (FPSC's) shall be Woodford model B65, Josam, Zurn, Mifab, Wade, Prier or equal; non-freeze type, recessed box with chrome plated face, vacuum breaker, hose connection, integral stop and loose T key.

1. Note that there are several locations of freeze-proof sillcocks around the building near grade and serving the roof level.

C. Roof hydrants shall be Woodford model RHY2-MS, Josam, Zurn, Mifab, Wade, Prier or equal and shall have the following features:

1. Rod guide eliminates side pull on rod, reduces wear on packing, packing nut and stem.
2. Adjustable link for easy adjustment and positive lever lock position.
3. One piece variable flow plunger with large cushion type seal for longer life is not easily damaged and assures shut-off even when foreign particles are present,
4. All hydrant repairs can be made from top of unit without removing hydrant.
5. Hose connection backflow preventer: Model #50HF with ¾" hose connection, ASSE 1052 Listed, field testable dual check holds against 125 PSI backflow pressure.
6. 1" NPT female inlet connection
7. 1-1/4" US made galvanized pipe casing.
8. 1/8" NPT drain hole (must be piped to a drain location)
9. Mounting System – must be ordered separately for hydrant support.

2.31 ROOF DRAINS

A. Roof drains shall be as specified hereinafter, Zurn, Jay R. Smith, Josam, Mifab, Froet**,** Wade or Watts Drainage. Drains shall be cast iron with clamping device for making watertight connection. Free openings through strainer shall be twice area of drain outlet. Provide 4 lb. lead flashing 12" in diameter greater than outside diameter of drain collar. Note that bi-functional roof drains are acceptable.

B. RD-1: Zurn model #ZC163-SC-W4 or equal, combination 15" diameter roof drain and overflow drain (24" apart), Dura-coated cast iron bodies with combination membrane flashing clamp/gravel guards, double Top-Set deck plate (48"x24"), low silhouette cast iron domes; no-hub outlets; 4" internal water dam on overflow drain; provide underdeck clamp and/or extension as required by the application.

C. RD-2: Zurn model #ZC100-DP 15" diameter roof drain with cast iron dome, Dura-coated cast iron body with combination membrane flashing clamp/gravel guard, Top-Set® deck plate.

D. Emergency Roof Drain Downspout Nozzle Outlet: Zurn #Z199-SS, MIFAB® Series R1960-F, or approved equal downspout nozzle, all nickel bronze body, optional threaded or no-hub inlet and decorative face of wall flange and outlet nozzle with removable stainless screen. Note: the screen should be removable and easily reinstalled or not installed at all.

E. At every RD-1 roof drain, provide a Roof Drain Marker to identify the location of the roof drain if it is buried. The Roof Drain Marker shall by similar to the following:

1. Basis-of-Design Product: Provide roof drain markers manufactured by Roof Drain Marker Co., LLC., West Bridgewater, MA; (877) 571-6644; email: lmay@roofdrainmarker.com; www.roofdrainmarker.com. Alternates product manufacturers are Roof Safety Marker or Hy-tech Roof Drains.

2. Roof Drain Marker: Drain dome-mounted vertical fiberglass flag marker secured in aluminum socket in turn secured with pre-punched aluminum bracket configured for through-bolting to roof drain dome.
   Flag Marker: Pultruded fiber-reinforced polymer rod, 1/2 inch (12 mm) diameter by 48 inch (1219 mm) long, with reflective dual-colored reversible ends enabling marking of selected drains.
   Flexural Strength, minimum, ASTM D 790, 700,000 psi
   Impact Strength, minimum, ASTM D 256: 40 ft-lb/in.
   Marker Base: 1 by 1 by 4 inch (25 by 25 by 102 mm) extruded aluminum bar, ASTM B 209 (ASTM B 209M), with milled flag receiver, threaded flag set screw retainer, and threaded base.
   Flag Bracket: 1 by 11 by 0.063 inch (25 by 25 by 1.60 mm) aluminum plate bracket, ASTM B 221 (ASTM B 221M).
   Fasteners: Alloy Group 2 (A4) stainless-steel bolts, ASTM F 593 (ASTM F 738M), and nuts, ASTM F 594 (ASTM F 836M).

2.32 EXPANSION COMPENSATORS

A. Flexible expansion loops of the size and type noted on the drawings shall be "Metraloop" by Metraflex or approved equal by Flexicraft Industries, Kinetics Noise Control or Engineered Flexible Products Inc., constructed of materials compatible for the service(s) intended and as shown, with axial movements of 4". Flexible loops shall impart minimal thrust loads on the piping, and be guided and anchored in accordance with manufacturer's recommendations. Flexible loops shall consist of two flexible sections, and a 180 return bend with a drain/air release fitting. Flexible loops for potable water systems shall be approved by the Massachusetts Plumbing Board.

B. The alternate methods to using the specified flexible expansion loops are standard expansion loops (as shown on the drawings if there is room) and/or expansion compensators/joints with female copper sweat ends and stainless steel bellows and pipe/shell.

C. There are several building expansion joints on this project. Anytime the piping crosses a building expansion joint, braided stainless steel piping should be utilized on either side of the joint so the piping can move with the building independently from the fixed piping system. These are indicated on the drawings. Note that standard expansion loops will not work at these locations.

2.33 GAS FIRED BOILER FLUE VENT AND COMBUSTION AIR PIPING

A. Furnish and install, where shown on the Drawings, domestic hot water boiler flue and combustion air venting in accordance with the boiler manufacturer's published installation instructions.

B. The boiler shall be installed and vented with a Direct Vent system with vertical roof termination of the positive pressure flue vent. The positive pressure vent shall be as follows:

1. The vent shall be of the single wall, factory-built type, designed for use in conjunction with Category II, or IV condensing gas fired appliances, condensing oil fired appliances or as specified by the heating equipment manufacturer.
2. Maximum continuous flue gas temperature shall not exceed 230 degrees F.
3. Vent shall be listed for a maximum positive pressure rating of 20” w.c.
4. The vent system shall be continuous from the appliance’s flue outlet to the vent termination outside the building. All systems components shall be UL/cUL listed and supplied by the same manufacturer.

Diameter		*Wall thickness extruded pipes*			
Diameter (mm)	*diameter (inch)*	*min (mm)*	*max (mm)*	*min (inch)*	*max (inch)*
DN 60	2"	1.7	2.2	0.0669	0.0866
DN 80	3"	1.8	2.4	0.0709	0.0945
DN 110	4"	2.4	3.2	0.0945	0.1260
DN 125	5"	2.7	3.7	0.1063	0.1457
DN 160	6"	2.9	4.5	0.1142	0.1772
DN 200	8"	3.5	4.5	0.1378	0.1772
DN 250	10"	3.3	4.7	0.1299	0.1850
DN 315	12"	4.2	5.8	0.1654	0.2283

5. All systems components such as vent supports, roof or wall penetrations, terminations, appliance connectors and drain fittings required to install the vent system shall be UL/cUL listed and provided by the vent manufacturer.
6. All systems components shall include a factory- installed gasket in their female-end to render the vent air and water tight when the male/female ends are pushed together as per manufacturer’s instructions. Vent systems requiring field installed sealants or compounds shall not be acceptable.
7. Vent layout shall be designed and installed in compliance with manufacturer’s installation instructions and all applicable local codes.

C. The boiler shall be installed with piped combustion air to a louver plenum furnished by the HVAC Contractor. The combustion air venting shall be schedule 40 CPVC, Polypropylene or Stainless Steel sealed vent material terminating at the louver plenum. Foam Core pipe is not

an approved material for intake piping. Refer to boiler manufacturer's installation instructions for allowed materials and installation guidelines.

D. Provide all components required for complete system. Venting systems including, but not limited to, pipe sections, tees and elbows, drains, cleanouts, supports, variable lengths, termination caps and screens.

E. Flue vent low point drains shall be piped to an acid neutralizing tank furnished by boiler manufacturer. Pipe and install in accordance with manufacturers recommendations.

F. Vent shall be InnoFlue® manufactured by Centrotherm, DuraVent PolyPro, or approved equal.

2.34 HEATING BOILER FLUE PIPING – By HVAC Contractor

2.35 WATER SUB-METERS

A. Furnish and install water sub-meters on the domestic water system at the boiler water feed and serving the domestic water system to meet LEED criteria for metering. The water sub-meters shall be as follows:

1. For the 1" boiler/chiller water feed, provide BadgerMeter Recordall Cold Water Bronze Disc Meter model #25-RTR rated for 0.5 GPM – 25 GPM with 5/8" x 3/4" piping connections. The water meter complies with ANSI/AWWA standard C700 and consists of three basic components: meter housing, measuring chamber and permanently sealed register. The water meter is bronze with externally threaded spuds. The meter uses a direct magnetic drive, through the use of high-strength magnets, providing positive reliable and dependable register coupling for straight-reading, remote or automatic reading options. The water meter will provide a digital pulse output to the EMS system for monitoring to meet LEED requirements.
2. For the 4" cold water feed to the domestic hot water system, provide BadgerMeter Recordall Cold Water Bronze Disc Meter model #35-RTR rated for 0.75 GPM – 35 GPM with 3/4" piping connections. The water meter complies with ANSI/AWWA standard C700 and consists of three basic components: meter housing, measuring chamber and permanently sealed register. The water meter is bronze with externally threaded spuds. The meter uses a direct magnetic drive, through the use of high-strength magnets, providing positive reliable and dependable register coupling for straight-reading, remote or automatic reading options. The water meter will provide a digital pulse output to the EMS system for monitoring to meet LEED requirements.
3. Alternate water meter manufacturers are Neptune, Sensus, H2O Degree or approved equal.

2.36 NATURAL GAS SUB-METERING

A. Provide gas sub-meter for the domestic water boilers similar to the following:

1. Provide Elster American Meter model #AC-630 Diaphragm Meter or approved equal; die-cast aluminum case; oil-impregnated self-lubricating bushings; molded convoluted diaphragms for smooth operation & long life; rigid reinforced flag rods for positive alignment and sustained accuracy; graphite-filled phenolic valves to minimize wear; long life low friction grommet seals; single coat polyester primer with high solids polyurethane top coat; security seals that indicate tampering.
2. Provide optional remote volume pulser.

B. Provide gas sub-meter for the heating boilers similar to the following:

1. Provide Romet “Imperial” Rotary Gas Meter model #RM-5000 or approved equal; positive displacement type meter that use the classic “roots” principle of measurement; cast aluminum body and covers; extruded aluminum impellers; high grade alloyed steel impeller shafts; synthetic elastomer o-ring/gaskets; high carbon steel bearings; steel allot timing gears and reduction gears. Maximum Flow Rate = 5,000 CFH. Maximum pressure drop = 0.96” w.c. Start Flow = 4.0 CFH. Weight = 32 LBS.
2. Description: Two counter-rotating impellers spin inside the pressurized precision machined measuring chamber. The rotation is transmitted via a magnetic couple to the mechanical index. An odometer style index totalizes the raw “uncorrected” volume. The uncorrected volume can be transmitted via an integrated Low Frequency Pulser to a remote mounted Index, PLC, or Energy Management System.

C. Alternate gas sub-meters shall be Onicon Inc. #F-5300 Series Thermal Mass Flow Meter with #D-100 Flow Display with Network Interface. Provide Onicon Inc. #N-100 Network Interface Module.

D. The inlet gas pressure to the gas sub-meters is 7”w.c.

2.37 MOTORS, STARTERS, AND WIRING

A. Provide motors and controls, and furnish starters, for plumbing equipment. Provide control and other related wiring, including interlocks. Power wiring to panelboards, disconnect switches, starters and motors shall be provided by Division 26000. Starters that are not integral to equipment shall be installed and wired under Division 26000 and furnished under this Section.

B. All motors and starters shall comply with specifications included in Division 260000.

2.38 COMPOUND TYPE COLD WATER METER – DOMESTIC WATER SERVICE @ SCHOOL

A. These specifications are in compliance with the latest revision of AWWA Standard C702 with certain exceptions as noted below. All specifications meet or exceed the latest revision on AWWA C702.

B. Compound meters shall consist of a combination of an AWWA Class II turbine meter for measuring high rates of flow and a nutating disc type positive displacement meter for measuring low rates of flow enclosed in a single maincase. An automatic valve shall direct flows through the disc meter at low flow rates and through the turbine meter at high flow rates. At high flow rates, the automatic valve shall also serve to restrict the flow through the disc meter to minimize wear.

C. The capacity of the meter in terms of normal operating range, maximum loss of head, and maximum continuous flow shall be as shown below:

Size	Normal Operating Range (GPM)	Max. Head Loss at Cont Flow (psi)	Max. Continuous Flow (GPM)	Max. Capacity Flow (GPM)	Min. Test Flow (GPM)
3"	1/2 – 450	6	350	450	1/4

D. The size of the meters shall be determined by the nominal size (in inches) of the opening in the inlet and outlet flanges. Overall lengths of the meters shall be as follows:

Size	Laying Length	Max. Height from Center with Local Register
3"	17"	7-3/4"

E. Casing bolts shall be made of type 316 stainless steel.

F. Maincases shall be flanged. The 3" size shall have optional oval flanges or round flanges per Table 4, AWWA C702.

G. The maincase and cover shall be sand cast of water works bronze containing not less than 75% copper. The size, model, manufacturer's trademark, and arrows indicating direction of flow shall be cast in raised characters on both sides of the maincase. The size and arrows indicating direction of flow shall be cast in raised characters on the housing cover. A 1-1/2" test plug shall be located on the maincase cover for the purpose of field testing the meter. The maincase shall have a single drain plug located on either side of the maincase or near the outlet end of the meter casing.

H. A single magnetic-drive register shall record the flow of the turbine and disc meters and a single number wheel stack shall sum the registration of the meter. Registers shall be permanently sealed, electronic encoder register (EER) indicating in cubic feet. Registers shall be permanently roll sealed, straight reading, indicating in gallons, cubic feet, or cubic meters. Registers shall include a center-sweep test hand, meter size and a glass lens.

I. Register boxes and covers shall be of bronze or thermoplastic composition. The name of the manufacturer, manufacturer trademark and the meter serial number shall be clearly identifiable and located on the register box cover.

J. The register box shall be secured to meter bayonet with a seal wire tamper resistant screw.

K. The meter serial number shall be imprinted on the meter flange or cover as well as the register box cover.

L. The compound measuring assembly shall be a self-contained unit, attached to the cover for easy field removal. The turbine rotor spindle shall be stainless steel with a ceramic bearing and endstone.

1. The nutating disc chamber shall be a self-contained unit mounted on the cover and easily removable from the cover. It shall conform to AWWA Standard C-700 for the following size: 2" - 5/8" disc.

M. One vertical 1-1/2" NPT tapped boss shall be provided on the housing near the outlet for use during field performance testing purposes or as a tap for pressure recording.

N. The automatic valve shall be of the weight type and uses gravity for operation. All valve parts shall be made of water works bronze, stainless steel, or a suitable polymer with a replaceable semi-hard rubber seal. Only the cover must be removed to gain access to the valve for inspection or service.

O. A strainer shall be provided for the disc meter. It shall be easily removable and have an effective straining area of at least double the disc meter inlet.

P. Registration accuracy over the normal operating range shall be 98.5% to 101.5%. Registration at the crossover shall not be less than 95%. Registration at the low flow rate shall not be less than 95%.

Q. All meters shall be equipped with a digital encoder register per AWWA C707, shall meet all AWWA C702 performance standards, and shall include all required hardware for installation. The digital encoder will allow connectivity to a close proximity read system, a radio frequency read system and a telephone in-bound system.

R. If water meters for the domestic water system and site irrigation system are furnished by the City of Worcester, then they must come standard with pulse contacts to be wired to the BMS system for tracking of water usage to meet LEED requirements. Note that the project must compile monthly and annual summaries of results for each subsystem metered. The measurements and verification period shall cover a period of no less than one year of post-construction occupancy.

S. Acceptable meters shall be the Badger Recordall Compound or approved equal.

T. Water meters for site irrigation system and for outdoor toilet and storage building shall be similar, but not the same size. See plans or coordinate with the Worcester DPW for water meter sizes.

2.39 TIMECLOCKS

A. Furnish and install, where indicated on the Drawings (i.e. for the RP-1 & 2, RP-3 & RP-4 pumps), multi-purpose digital timeclocks as manufactured by Tork, Model DZS-100, or approved equal.

B. Unit shall consist of:

1. On/off time with override.
2. Unit controllers shall have capability to program on one (1) minute intervals.
3. Unit can program in AM/PM or 24 hour format.
4. LED display.
5. 365-day capability.
6. 120 Volt control.
7. Solenoid valve.

2.40 EXTERIOR CONCRETE GREASE INTERCEPTOR – FURNISHED AND INSTALLED BY SITE CONTRACTOR, BUT PIPING TO & FROM & PIPING INSIDE TANK BY PLUMBER

A. The exterior concrete grease interceptor will be submitted, approved and released for manufacture under the Site Bid Package. The detail on the drawing (15/P4.1) was dimensioned based on the approved unit. The piping indicated in this detail must be installed by the Plumbing Subcontractor. Note that the exterior concrete grease interceptor will be installed when it arrives to the site by the Site Contractor.

2.41 HOT AND COLD WATE HOSE STATION AND MIXING UNIT (HS-1)

A. Furnish and install Armstrong model #3033 Hot and Cold Water Hose Station and Mixing Unit Assembly, standard materials, or approved equal, where shown on the drawings. It shall have a model 320 ¾” inlets/outlet thermostatic mixing valve (TMV) of disposable cartridge construction. TMV features unique full range temperature control from full cold to field adjustable maximum temperature limit stop in a single handle turn. TMV can be set and

locked to a single temperature and will hold outlet temperature ±2°F in the event of inlet pressure and/or temperature fluctuation/change. Thermal shutdown capability protects operator in the event of an inlet supply failure. This model includes integral tandem valve comprising of two (2) full port ball valves cross-linked by a stainless steel bridge piece and lever for simultaneous on/off control of both inlet supplies. Outlet thermometer of stainless steel construction and shatter-proof Lexan lens. Unit is mounted on a heavy-duty stainless steel single-piece hose rack that is suitable for wall or column installation. Supplied with 25 feet white 300 PSI/200°F rated washdown hose with “live” swivel adaptors. Rubber cushioned 10 GPM rated water saver spray nozzle and nozzle hook supplied as standard. Unit is supplied fully assembled and pressure tested with strain relief and ¾” coupling for hose attachment. Inlet check valves are required.

B. Acceptable manufacturers are Armstrong, SuperKlean Washdown Products, Strahman Valves Inc., or approved equal.

2.42 TWO STAGE pH NEUTRALIZATION SYSTEM

A. The laboratory waste pH neutralization system shall be supplied as a complete, integrated process system by a single supplier. The system shall be as manufactured by Concorp, Inc. of Acton, Massachusetts. The system shall be Concorp Model PHS/2-500-SP, or approved equal.

B. The two-stage active chemical feed pH neutralization system normally operates on a semi-cntinuous basis. The pH neutralization system is designed to have the laboratory wasteater flow by graviry to the treatment tank, where the pH is adjusted in two individual chambers in series. After treatment, the wastewater is normally periodically pump discharged to the outlet monitoring assembly, where the discharge pH and flow rate are measured and recorded. The effluent then flows by gravtiy to the sewer. The two treatment chambers each have a nominal total volume of 500 fallons.

1. The system accepts incoming streams of aqueous solutions. It discharges treated liquids by periodic pumped flow from the second stage of the treatment tank during normal operation. The liquid first enters the neutralization tank. The liquid in each reaction chamber is mixed by a top-entering agitator, which rapidly disperses all new incoming liquids (including treatment chemicals) to provide a high degree of uniformity or concentration in the tank.

2. The system is designed to use a semi-batch pump in the second treatment stage compartment that uses a level control unit with a preset pump-out range. The level sensor unit controls the pump within a finite depth (about 6” – 10” below the outlet) which also is tied to the treatment tank and outlet pH controls.

3. A sensor immersed in each chamber continuously measures the pH of the liquids in the treatment tank. The sensors are connected to a microprocessor-based controller with full bi-directional proportional capability for each chamber. The controller automatically initiates treatment in each tank when the measured pH exceeds either of the two (high and low) setpoints for the tank. The controller not only starts and stops the metering pumps, but also directly regulates the pumping rate of each pump. The reagents used are 25-93% sulfuric acid and 25-50% sodium hydroxide (other concentrations and reagents can be accommodated by adjustment to the equipment).

4. The discharge from the treatment tank, either normally pumped or by overflow, passes through a pH monitoring assembly. The monitoring trap has a pH sensor mounted in the assembly. With this sensor, the pH of the discharged liquid is monitored continuously

after treatment. A circular chart recorder records this pH measurement. High and low pH alarms are included and will provide both audible and visual alarm indication of either condition.

C. Equipment Specifications - pH Neutralization System:

1. System Tank:

Quantity:	one (1)
Type:	rectangular, flat bottom, with welded cover, two-chamber neutralization tank
Model:	Concorp Model PHP/2-500-SP
Volume:	2480 gallons nominal volume total, 500 gallons nominal working volume each reaction chamber
Size:	52” x 96” x 102” deep (nominal overall)
Material:	polypropylene with tubular steel support girths (2”x2” epoxy coated)
Baffles:	One baffle is a combnation V-type baffle and underflow weir for outlet
Walls:	1/2" thick polypropylene
Bottom:	1/2" thick polypropylene
Fittings:	Inlet: 6" Outlet: 6” PP Vent: 4" Overflow: 4" PP
Cover:	1/2" minimum thickness with stiffeners and/or supports. Cover shall be removable, have an access port, stainless steel hardware to bolt cover to tank.
Cover Fittings:	Fittings for removable pH electrode, mixer seal, chemical injection ports.
Other Specs.:	Placement and elevations of fittings are to be confirmed by installing contractor and engineer pripr to final release.

Due to the site limitations, the tank piping connections need to be about 50” for the inlet and 49” for the outlet fromt eh bottom of the pit. Also the tank cover to be fastened to the tank top rim so that the bolts are removable from only the top. See tank drawing and notes and details.

Installation:	Tank must be mounted to a flat stable surface of contrete or other surface that can provide sufficient support of tank weight. Care should be taken to ensure all foreign objects are removed from the foundation before installation of the tank.

2. Mixers for Neutralization Tanks:

Quantity:	two (2)
Type:	top entry, fixed mount, continuous-duty, 1.15 min. service factor
Model:	Dynamix DMX or equivalent
Motor:	1/2 HP minimum, 1750 rpm, TEFC, 120 VAC, 1 phase, 60 Hz. NEMA "56C" flange mounting, high efficiency
Gear Drive:	Helical gear reduction
Mount:	Fixed plate mount unit, vertical on-center
Pumping Capacity:	2-3 tank volume turns per minute
Mixer Shaft:	1-1/4" dia. x 84” long minimum, type 316 stainless steel
Mixer Impeller:	(1) 12” diameter minimum terbine or axial flow-hydrofoil impeller, type 316 stainless steel

The unit is a special gear drive mixer. The motor is a standard NEMA “C” flange

mount TEFC. The impellar is a high-efficiency three-bladed impellar and is constructed of machined type 316 stainless steel. The shaft is solid, machnied type 316 stainless steel and is 1.25” in diameter for hevy loads and extended shaft. The shaft is attached to the motor by a heavy-duty coupling with setscrews. The seal for the agitator shaft through the top of the tank is a gasketed seal to minimize leakage of fumes from the tank. The mixer is mounted to the reactor via a welded epoxy coated steel and polypropylene support bracket. The mixer is operated by an On/Off switch located in the main control panel. The main control panel will include a control ciruit for the mixer.

3. Chemical Storage:

Quantity:	two (2) (one acid and one caustic)
Type:	cylindrical, flat-bottom, closed top drum Chemical Drum DOT approved shipping containers
Covers:	molded high-density polyethylene
Volume:	15 gallons, nominal
Diameter:	21" Height: 39" Wall Thickness: 3/16"
Material:	High-density polyethylene

Tanks shall have fittings for connection to the tubing to chemical metering pumps and low-level controls. A fitting shall be provided for the convenient filling and re-closing of the tanks. Low level control switches shall be provided for each chemical storage tank, which shall be wired to the system control panel. The float switches shall be constructed from polypropylene wetted parts.

4. Chemical Reagent Containment Pan:

Quantity:	two (2)
Containment:	acid and caustic drum secondary containment two chemical metering pump mounting shelves.
Size:	26” x 26” x 6” high, nominal

The reagent station will have two containment pans, one for each of the chemical feel tanks. The reagent pumps shall be mounted on a polypropylene shelf. The units shall be designed to provide two separate compartments in which the chemical reagents can be located. The 15 gallon DOT shipping containers are to be placed on separate spill containment pallets.

The chemical feed tubing from the shipping containers to the metering pump shall be provided with tubing connectors for ease of service and to facilitate the changing of the chemical reagent drums. The 15-gallon reagent drums are to be placed in the secondary containment. The chemical feed tubing from the metering pumps to the neutralization tanks shall be installed in PVC schedule 40 piping or conduit for secondary containment and protection.

5. Chemical Metering Pumps:

Quantity:	four (4)
Capacity:	4 gallons per hour minimum
Model:	Prominent Fluid Controls BT4b 0220PPE
Turndown Ratio:	1200:1 (minimum)
Wetted Materials:	Polypropylene, PTFE, Viton A, and Duran 50®
Power Requirements:	110 VAC, 60 Hz, 13W average (at min. stroking rate)
Control Input:	pulse-contact direct, manual control
Enclosure:	fiberglass-reinforced Noryl® plastic, NEMA 4 rated

Pump is microprocessor-controlled with an electro-solenoid drive. All functions are monitored and controlled through a user interface on the front panel of the pump. Overvoltage, overtemperature, and power consumption overload are monitored by the microprocessor for safety shutdown. Pump stroke rate is quartz-precision controlled (maximum rate is 180 strokes per minute). The pump stroke rate can also be externally regulated by a low-speed digital pulse. Pulse input is direct without requiring additional conversion hardware. Pumping rate is scale to the input current and can be either direct or inverse to the signal, depending on programming. Pump controls have NEMA-4 splash protection and a built-in cover for the face of the pump (pump is rated NEMA-4 without cover).

The diaphragm is steel encased in a bonded elastomer with the exposed face layered with pure polytetrafluoroethylene for maximum chemical resistant. The diaphragm has a maximum deflection of 1.25 mm for extended service life. The solenoid drive has a special shock-dampening design to reduce drive wear and noise. The liquid end has double-ball check-valves for both suction and discharge for maximum repeatability and reliability. A ball-check foot valve and a spring-loaded ball-check injection valve are also included. Anti-siphon action is provided at both the discharge valve of the pump and at the injection valve of the tank. The liquids will be pumped through seamless polyethylene tubing. The chemical feed tubing from the metering pumps to the neutralization tank shall be installed in PVC schedule 40 piping or conduit for secondary containment and protection.

6. pH Electrodes Assemblies:

Quantity:	three (3) Tank 1, Tank 2, outlet
Type:	Glass membtrane, Ag/AgCl cell sensor with gel-filled double-injection reference, with reference ad temperature sensor.
Mount:	Signet 3-2726-10, Electrode

The pH electrodes are double junction, gel-filled, permanent-reference glass sensors. The measurement range is pH 0 to 14. The electrode assembly for the treatment tank ionserts through and fits to a fitting on the cover of the tank to securely hold the assembly in place. The electrode from the monitor comes with a flow-through housing that installed into the discharge pipe. All necesart moutning and installation hardware for the electriodes and sensors is provided. There are no special tuols required to remove the electrode assemblies for cleanng and calibration. The cable to the electrode will be run in non-metallic liquid-tight flexible conduit to protect the cable and provide maximum flexibility for ease of maintenance.

7. pH Transmitters:

Quantity:	three (3) Tank 1, Tank 2, outlet
Model:	Signet 3-2750-3, Signet 3-8050-2 with Easy Cal
Measurement Range:	pH 0 to 14
Power:	24v dc
Input:	direct pH sensor input, 15’ cable min.
Output:	analog output (4 - 20 mA)

The pH transmitters are field remote mounted, in close proximity to the system control panel. The electronics are protected from electromagnetic and radio-frequency interference. The pH transmitters will provide a 4-20 mA control signal to the system controller. The pH transmitters are mounted in a NEMA 4 enclosure.

8. System Controller:

Quantity:	one (1)
Model:	Alllen Bradley Micro830, 2080-LC30-48QWB
Controller:	Type Microprocessor-based programmable logic controller (PLC)
Input:	28 discrete inputs (on/off)
	4 analog inputs (402- mA)
Outputs:	20 relay outputs, 2A @ 250 VAC max.
	4 analog inputs (4-20 mA)
	2 analog outputs (4-20 mA)
Interface:	Allen Bradley Component Graphic Terminal PV800
Display:	color-graphic touch screen display

The System Controller is a programmable logic controller programmed and configured for pH control, effluant flow measurement and totalization, general system operation, and alarm indication and acuation. All functions and data are storage in EEPROM non-volatile momory. Typical scan rate as progreammed approximately 20 ms.

The operator interface is a color touch screen with operator entry buttons. The interface will be connected to the PLC via standard Allen-Bradley serial communications network. Maintenance aind calibration can be passwork protect for security.

The controller.interface combianation is set-up for future expansion and network capability to allow for remote link and/or remote interface units. This controller can be expanded through additional I/O modules, networked remote I/O and additional stand-alone controllers. Remote monitoried can be implemented through networked interfaces, standard computer networking or via dial-up modem access. Future expansion and remote monitoring require aditional, optional hardware and progreamming.

True b-directional proportional pH control provide greater capacity for extreme pH deviations while limiting overshoot. This allows the neutralizing system to handle fluctuations in pH much better than on/off ocntrol systems, minimize overshoot and reduce chemical consumption. Each of the controler processes has independent settings, controls and libraries of tuning parameters. Standard features include isolated input, septoint and output limits. This controller will be configured with two direct outputs for the acid and alkili metering pumps for the neutralization tank. This will allow the controller to directly regulate the actual pumping rate of the metering pumps. No additional hardware will be required to convert signals for the metering.

9. Recorder Specifications:

Quantity:	one (1)
Recorder Type:	Microprocessor based 10” circular chart recorder
Model:	Concorp DR5000
Measurement:	pH 0.00 to 14.00
Display:	4 digit LED display, high-intensity, 0.56 inches high
Input:	4-20 mA input from output pH analyzer
Chart Rotation:	7 day (chart rotation speed can be user configurable)
Pen Resolution:	0.15% of chart span
Measurement Accuracy:	±0.25% of full scale
Scan Rate:	1 scan per second

The unit is a single pen micropressor baed, circular-chart recorder. This model is equipped to measure a 4-20 mA direct-current signal (such as provided by the pH

analyzer). A dc servo-motor is used to drive the marking pen. The marking pen is a disposable pen cartridge. The colors of the pen used are red or green (others available).

The charts used are 10” in diameter and printed with pH 0-14 markings and hourly markings for pH recording. One box of 100 charts and two pens are provided with the recorder. The chart rotaion speed is one revolution per week.These charts provide archive-quality permament record that is no temperature or pressur sensitive. These records are easily reproduced for record-keeping purposes.

The recored is equippred with a digital dosplay. All programming is via tactile feedback membrame keys. The door window is clear palstic to allow viewing of the entire charg. The instrument case is structural foam and is NEMA 4 rated. The recorder operates on 110 VAC, 60 Hz power.

10. Pump:

Quantity:	two (2)
Model:	Elbara EPD-3
Type:	stainless steel submersible sump pump
Flow / Head:	30 gpm @ 15 ft TDH minimum
Motor:	1/3 HP, 115 VAC, 60 Hz, single phase
Material:	Stainless steel, Polypropylene

The pump is to be operatred by a hands/on/off switch locted in the main control panel. The main control panel will include control circuit for the pump. Pump to be mounted with polypropylene access plate

11. Pump Discharge Valve:

Quantity:	two (2) True-Union Ball Valve and Check Valve
Material:	Polypropylene with EPDM seals
Type:	1-1/2” valve

Pumops to have a check and ball valve in the discharge line.

12. Pump Discharge Tank Level Control:

Quantity:	One (1)
Type:	solid state electronic float switch
Material:	sps plastic wetted parts
Model:	Level Guard Z24803PTZ

Level sensor is discrete point level switch. The switch provides pump automated level control for pump station discharge operation. The pump operation is controlled via the PLC based on the tank water lever as well as pH. The sensor shall be set for pump off and pump on. The tanks has separate high water level float sensors and alarms.

13. Outlet pH Monitoring Assembly:

Quantity:	one (1)
Configuration:	Custom inlet tee to accept pH sensor
Size:	6” pipe (IPS)
Material:	Polypropylene

This unit is integrated combination outlet-monitoring trap with pH sensor mounted fitting and a sample tap fitting; Unit will be constructed of standard 6” polypropylene

laboratory wste pipe and fittings. The sampling assembly consists ot a trapping with ¼" ball valves with hose bard connector.

14. Control Panel:

Quantity:	one (1)
Size:	20" wide x 24" high x 10" deep, nominal
Enclosure:	NEMA 4 Industrial control Panel

The panel enclosure shall be NEMA 4X rated (water-tight and dust-proof). All external connectors and cable outlets shall be water-resistant.

The instrument panel will be arranged to give an orderly presentation of the instrumentation. The enclosure shall have a hinged panel that provides ready access to all instruments and accessories for servicing. All items shall be so wired and mounted that, in general, any one item can be removed without interruption of the other items. No zero-based analog signals shall be used between instruments.

An audible and visual alarm annunciation will be supplied as part of the panel system to provide indication of the following conditions:

Power On	
Mixer 1 On	Mixer 2 On
Pump 1 On	Pump 2 On
Low Effluent pH	High Effluent pH
Low Acid in Storage Tank	Low Alkali in Storage Tank
Tank High Water	General Trouble

All instruments will be mounted semi-flush on the front of the panel in a manner such that all basic controls and adjustments are accessible without unlatching or opening the panel itself. Power input is 120V, 1 phase. A main power disconnect conforming to OSHA lock-out/tag-out standards will be provided. Motor starters and overload relays will be provided for the mixer and pump motors. A transformer will be provided for control circuits and instruments. One dry alarm contact will be provided with terminals for a general remote alarm indication.

The control panel is to be mounted in the system footprint, connected to the primary system equipment It shall have provision for a set of remote alarm dry contacts for alarm connection to the building management system.

D. Recommended Spare Parts List:

1. pH electrode, Concorp part #3-2726-10
2. Metering pump spare parts kit, Concorp part #PfC/91.26.85.5

E. Required Lubricants: The only parts of the system normally requiring lubrivant are the mixed shaft seals, on the top of the neutralization tank. This seal should be perioduically lubricated with silicone grease. If this material is not readilty available, please contact Concorp. The mixer does not required a change of lubrication during normal operation.

F. Expendable and Consumable Materials:

1. Sulfuric Acid, 50% - 93% concentration recommended. Other acids may be substituted. Please contact Concorp for substitution recommendations. Rate of consumption of acid with depend on materials treated by system.
2. Sodium Hydroxide, 25% - 50% concentration recommended. Other alkalis may be substituted. Please contact Concorp for substitution recommendations. Rate of consumption of alkali with depend on materials treated by system.
3. Recorder Charts, Concorp part #PW/00214416. These charts are supplied in boxes of 100. This system is supplied with one box of charts.
4. Recorder Pens, Concorp part #PW/60500401. This system is supplied with two (2) pens.
5. pH Electrodes, Concorp part #3-2726-10. This system is supplied with three (3) units.

G. Services Provided with System

1. Interconnection wiring diagram and control panel schematic diagram.
2. Up to eight hours of field support for the installing contrator.
3. Initial system calibration and start-up by a factory technicial.
4. Up to four hours of operation and maintenance training for facilities personnel by a factory technicial.

H. Installation

1. All equipment and materials shall be furnished to the Plumbing Subcontractor by the manufacturer complete and in proper condition for installation. The entire system is furnished by the Plumbing Subcontractor.

2. The site plumbing contractor shall be responsible for installation of piping and mechanical components. The pH neutralization system shall be installed according to instructions and specifications provided by the system supplier and in compliance with state and local plumbing codes. The installing contractor shall also comply with all job specifications that are pertinent to this system.

3. pH electrode sensor assemblies shall be wired to the neutralization system in a manner as to facilitate cleaning, calibration, and maintenance of these sensors. Cables shall be run in flexible conduit to allow removal of the sensors for maintenance.

4. The chemical feed tubing shall be continuous PE tubing housed in pipe or large-bore tubing to shield against damage or leakage danger to personnel working near the system. The chemical tubing shall be installed in secondary containment piping from the reagent station to the chemical injection containment boxed on the top of each reactor.

5. The site interconnection piping, including manual isolation valves and fittings shall be provided and installed by the plumbing contractor.

6. Electrically, the system is wired as follows:

    a. The pH system has one power feed, which is to the power disconnect in the main panel.
    b. The system power feed is 120V, 1phase, 30 amps.
    c. All of the system equipment is powered from the main panel (this allows the motor protection as well as e-stop and power disconnect lockout).
    d. The mixers are pumps are each to be hard wired from the tank to the panel. Each are home runs wired from the device to the panel motor starter.
    e. The chemical metering pumps power and control cable are each wired to the control panel.

f. The pH sensors and level sensors are low voltage which are home runs wired from device to control panel.

7. Since the tank is located in a pit and the control panel wall mounted, the system components need to be site wired. Each mixer and transfer pump is wired separately so that they are protected by a circuit breaker and motor started. This also allows the power disconnect and e-stop to function for these items. The chemical metering pumps are wired from the auxiliary of the mixer starters so that in the even the mixed is not running (tripped or powered off), the chemical metering pumps are stopped for safety. The instrument wiring are each low voltage (24 vdc). The wiring is typically run as instrument cable (18gage twisted pair wired with shield and drain). The site wiring is usually handled by either the site electrician or the plumber's electrical subcontractor. The instrument connections, testing, startup and calibration is usually performed by the MFR's technician once the site installation is ready.

I. Start-up and Training

1. The system manufacturer shall provide on-site assistance for the installing contractors amounting to a minimum of eight hours at the job site.

2. The system manufacturer shall provide complete start-up services. These services shall include adjustment of all equipment and controls, calibration of sensors and instrumentation, tuning of the control systems, check of all alarm functions, and verification of proper operation. The system startup and tuning shall be performed by a factory trained engineer and licensed wastewater treatment operator.

3. A minimum of 15 gallons of 25-50% sulfuric acid and 15 gallons of 25-50% sodium hydroxide shall be included for the initial operation of the system by the plumbing contractor.

4. The system manufacturer shall provide not less than three manuals that include overall operating, repair and maintenance instructions. In addition to these instructions, any factory manuals for pre-manufactured sub-component equipment shall be included in the system manual.

5. The system manufacturer shall provide instruction to the designated personnel of the owner or operator of the system. This instruction shall include operation of the system, calibration and maintenance, technical explanation of pH, neutralization, and local discharge requirements.

J. Warranties/Maintenance: All equipment and materials comprising the system shall be warranted against defects in materials or workmanship for a period of one year from the date of substantial completion. This warranty shall exclude consumed materials such as charts, pens, chemicals, electrodes, etc.

2.43 ELECTRICAL WORK

A. The Plumbing Trade Contractor shall hire the project electrician to perform all low voltage and control wiring as required by code. Minimum gauge of all control wiring is 18 AWG and shall be plenum rated. This is not extra electrical work as it must be carried in the Plumbers pricing.

1. Wiring of the science rooms gas detection / emergency gas shut-off panels with the gas detectors

2. Wiring of the pH neutralizing system panel and wiring from the panel to the system components. See paragraph 2.42.H.6 and 2.42.H.7 for additional information. Also, wiring for high water level alarms in the two pH neutralizing tanks.
3. Wiring of the radon fans (See detail on drawing P4.7 for wiring details – all wiring by Electrical Contractor).
4. Wiring of triplex, variable speed domestic water pressure booster system.
5. Wiring of domestic hot water heating system with associated boilers, pumps and system recirculation pumps including the emergency shower tempered water loop/
6. Wiring of the temperature maintenance electric heat trace system for portions of the domestic hot water piping system, namely the lab hot water piping.
7. Wiring of freeze protection electric heat trace on portions of the storm drain and sanitary waste systems that have the potential to freeze.
8. Wiring of grease line maintenance system from the interior grease interceptor to the exterior grease trap.
9. Wiring of elevator sump pumps (automatic pump with no control panel and plug-in style) and high water level alarm.

2.44 VIBRATION AND SEISMIC CONTROL FOR PLUMBING SYSTEMS

A. Intent:

1. All plumbing piping as noted on the equipment schedule or in the Specification shall be mounted on vibration isolators and with flexible connections to prevent the transmission of vibration and mechanically transmitted sound to the building structure. Vibration isolators shall be selected in accordance with the weight distribution so as to produce reasonably uniform deflections.
2. All isolators and isolation materials shall be of the same manufacturer and shall be certified by the manufacturer.
3. It is the intent of the seismic portion of this Specification to keep all mechanical building system components in place during a seismic event.
4. All such systems must be installed in strict accordance with seismic codes, component manufacturer's and building construction standards. Whenever a conflict occurs between the manufacturer's or construction standards, the most stringent shall apply.
5. This Specification is considered to be minimum requirements for seismic consideration and is not intended as a substitute for legislated, more stringent, national, state or local construction requirements (i.e. MA Codes, IBC Building Code, California Title 24, California OSHPD, or other requirements).
6. Any variance or non-compliance with these Specification requirements shall be corrected by the Plumbing Contractor in an approved manner.
7. Seismic restraints shall be designed in accordance with seismic force levels as detailed in Section H.

B. The work in this Section includes, but is not limited to, the following:

1. Vibration isolation for plumbing piping.
2. Equipment isolation bases.
3. Flexible piping connections.
4. Seismic restraints for isolated equipment.
5. Seismic restraints for non-isolated equipment.

6. Certification of seismic restraint designs and installation supervision.
7. Certification of seismic attachment of housekeeping pads.

C. Definitions:

1. Life Safety Systems: Not Applicable.

2. Positive Attachment: A positive attachment is defined as a cast-in anchor, a drill-in wedge anchor, a double sided beam clamp loaded perpendicular to a beam, or a welded or bolted connection to structure. Single sided "C" type beam clamps for support rods of overhead piping, ductwork, or any other equipment are not acceptable on this project as seismic anchor points.

3. Transverse Bracing: Restraint(s) applied to limit motion perpendicular to the centerline of the pipe, duct or conduit.

4. Longitudinal Bracing: Restraint(s) applied to limit motion parallel to the centerline of the pipe, duct or conduit.

D. Manufacturer's Data:

1. The manufacturer of vibration isolation and seismic restraints shall provide submittals for products as follows:

a. Descriptive Data:

(1) Catalog cuts or data sheets on vibration isolators and specific restraints detailing compliance with the Specification.

(2) Detailed schedules of flexible and rigidly mounted equipment, showing vibration isolators and seismic restraints by referencing numbered descriptive Drawings.

b. Shop Drawings:

(1) Submit fabrication details for equipment bases including dimensions, structural member sizes and support point locations.

(2) Provide all details of suspension and support for ceiling hung equipment.

(3) Where walls, floors, slabs or supplementary steel work are used for seismic restraint locations, details of acceptable attachment methods for ducts, conduit and pipe must be included and approved before the condition is accepted for installation. Restraint manufacturers' submittals must include spacing, static loads and seismic loads at all attachment and support points.

(4) Provide specific details of seismic restraints and anchors; include number, size and locations for each piece of equipment.

c. Seismic Certification and Analysis:

(1) Seismic restraint calculations must be provided for all connections of equipment to the structure. Calculations must be stamped by a registered professional engineer with at least five years of seismic design experience, licensed in the state of the job location.

(2) All restraining devices shall have a preapproval number from California OSHPD or some other recognized government agency showing maximum restraint ratings. Preapprovals based on independent testing are preferred to

preapprovals based on calculations. Where preapproved devices are not available, submittals based on independent testing are preferred. Calculations (including the combining of tensile and shear loadings) to support seismic restraint designs must be stamped by a registered professional engineer with at least five years of seismic design experience and licensed in the state of the job location. Testing and calculations must include both shear and tensile loads as well as one test or analysis at 45 to the weakest mode.

(3) Analysis must indicate calculated dead loads, static seismic loads and capacity of materials utilized for connections to equipment and structure. Analysis must detail anchoring methods, bolt diameter, embedment and/or welded length. All seismic restraint devices shall be designed to accept, without failure, the forces detailed in Section H acting through the equipment center of gravity. Overturning moments may exceed forces at ground level.

E. Code and Standards Requirements:

1. Typical Applicable Codes and Standards - most recent or enforced code:

a. Massachusetts State Building Code.

b. International Mechanical Code (IMC).

F. Manufacturer's Responsibility:

1. Manufacturer of vibration isolation and seismic control equipment shall have the following responsibilities:

a. Determine vibration isolation and seismic restraint sizes and locations.

b. Provide vibration isolation and seismic restraints as scheduled or specified.

c. Provide calculations and materials if required for restraint of unisolated equipment.

d. Provide installation instructions, drawings and trained field supervision to insure proper installation and performance.

G. Related Work:

1. Housekeeping Pads:

a. Housekeeping pad reinforcement and monolithic pad attachment to the structure details and design shall be prepared by the restraint vendor if not already indicated on the Drawings.

b. Housekeeping pads shall be coordinated with restraint vendor and sized to provide a minimum edge distance of ten (10) bolt diameters all around the outermost anchor bolt to allow development of full drill-in wedge anchor ratings. If cast-in anchors are to be used, the housekeeping pads shall be sized to accommodate the ACI requirements for bolt coverage and embedment.

2. Supplementary Support Steel: Plumbing Contractor shall supply supplementary support steel for all piping as required or specified.

3. Attachments: Plumbing Contractor shall supply restraint attachment plates cast into housekeeping pads, concrete inserts, double sided beam clamps, etc. in accordance with the requirements of the vibration vendor's calculations.

H. Seismic Force Levels

1. The force levels described in the building code shall be used on this project.

I. Product Intent:

1. All vibration isolators and seismic restraints described in this section shall be the product of a single manufacturer. Mason Industry's products are the basis of these Specifications; products of other manufacturers are acceptable provided their systems strictly comply with the Specification and have the approval of the specifying engineer. Submittals and certification sheets shall be in accordance with Section D.

2. For the purposes of this project, failure is defined as the discontinuance of any attachment point between equipment or structure, vertical permanent deformation greater than 1/8 in. and/or horizontal permanent deformation greater that 1/4 in.

J. Product Description: Vibration Isolators and Seismic Restraints:

1. Two (2) layers of 3/4 in. thick neoprene pad consisting of 2 in. square waffle modules separated horizontally by a 16 gauge galvanized shim. Load distribution plates shall be used as required. Pads shall be Type Super "W" as manufactured by Mason Industries, Inc.

2. Bridge-bearing neoprene mountings shall have a minimum static deflection of 0.2 in. and all directional seismic capability. The mount shall consist of a ductile iron casting containing two (2) separated and opposing molded neoprene elements. The elements shall prevent the central threaded sleeve and attachment bolt from contacting the casting during normal operation. The shock absorbing neoprene materials shall be compounded to bridge-bearing Specifications. Mountings shall have an Anchorage Preapproval "R" Number from OSHPD in the State of California verifying the maximum certified horizontal and vertical load ratings. Mountings shall be Type BR as manufactured by Mason Industries, Inc.

3. Sheet metal panels shall be bolted to the walls or supporting structure by assemblies consisting of a neoprene bushing cushioned between 2 steel sleeves. The outer sleeve prevents the sheet metal from cutting into the neoprene. Enlarge panel holes as required. Neoprene elements pass over the bushing to cushion the back panel horizontally. A steel disc covers the inside neoprene element and the inner steel sleeve is elongated to act as a stop so tightening the anchor bolts does not interfere with panel isolation in three (3) planes. Bushing assemblies can be applied to the ends of steel cross members where applicable. All neoprene shall be bridge bearing quality. Bushing assemblies shall be Type PB as manufactured by Mason Industries, Inc.

4. A one piece molded bridge bearing neoprene washer/bushing. The bushing shall surround the anchor bolt and have a flat washer face to avoid metal to metal contact. Neoprene bushings shall be Type HG as manufactured by Mason Industries, Inc.

5. Spring isolators shall be free standing and laterally stable without any housing and complete with a molded neoprene cup or 1/4 in. neoprene acoustical friction pad between the baseplate and the support. All mountings shall have leveling bolts that must be rigidly bolted to the equipment. Spring diameters shall be no less than 0.8 of the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. Submittals shall include spring

diameters, deflection, compressed spring height and leveling valves Type LV as manufactured by Mason Industries, Inc.

6. Restrained spring mountings shall have an SLF mounting as described in Specification 5, with a rigid housing that includes vertical limit stops to prevent spring extension when weight is removed. The housing shall serve as blocking during erection. A steel spacer shall be removed after adjustment. Installed and operating heights are equal. A minimum clearance of ½ inch shall be maintained around restraining bolds and between the housing and the spring so as not to interfere with the spring action. Limit stops shall be out of contact during normal operation. Since housings will be bolted or welded in position there must be an internal isolation pad. Housing shall be designed to resist all seismic forces. Mountings shall have Anchorage Preapproval “R” Number from OSHPD in the state of California certifying the maximum certified horizontal and vertical load ratings. Mountings shall be SLR as manufactured by Mason Industries, Inc.

7. Spring mountings as in Specification 5 built into a ductile iron or steel housing to provide all directional seismic snubbing. The snubber shall be adjustable vertically and allow a maximum of ¼ inch travel in all directions before contacting the resilient snubbing collars. Mountings shall have an Anchorage Preapproval “R” Number OSHPD in the State of California verifying the maximum certified horizontal and vertical load ratings. Mountings shall be SSLFH as manufactured by Mason Industries, Inc.

8. Air Springs shall be manufactured with upper and lower steel sections connected by a replaceable flexible nylon reinforced neoprene element. Air spring configuration shall be multiple bellows to achieve a maximum natural frequency of 3 Hz. Air Springs shall be designed for a burst pressure that is a minimum of three times the published maximum operating pressure. All air spring systems shall be connected to either the building control air or a supplementary air supply and equipped with three (3) leveling valves to maintain leveling within plus or minus 1/8 inch. Submittals shall include natural frequency load and damping tests performed by an independent lab or acoustician. Air Springs shall be Type MT and leveling valves Type LV as manufactured by Mason Industries, Inc.

9. Restrained air spring mountings shall have an MT air spring as described in Specification 8, within a rigid housing that includes vertical limit stops to prevent air spring extension when weight is removed. The housing shall serve as blocking during erection. A steel spacer shall be removed after adjustment. Installed and operating heights are equal. A minimum clearance of ½ in. shall be maintained around restraining bolts and between the housing and the air spring so as not to interfere with the air spring action. Limit stops shall be out of contact during normal operation. Housing shall be designed to resist all seismic forces. Mountings shall be SLR-MT as manufactured by Mason Industries, Inc.

10. Hangers shall consist of rigid steel frames containing minimum 1-1/4 in. thick neoprene elements at the top and a steel spring with general characteristics as in Specification 5 seated in a steel washer reinforced neoprene cup on the bottom. The neoprene element and the cup shall have neoprene bushings projecting through the steel box. To maintain stability the boxes shall not be articulated as clevis hangers nor the neoprene element stacked on top of the spring. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30 arc from side to side before contacting the rod bushing and short circuiting the spring. Submittals shall include a hanger Drawing showing the 30 capability. Hangers shall be Type 30N as manufactured by Mason Industries, Inc.

11. Hangers shall be as described in 10, but they shall be precompressed and locked at the rated deflection by means of a resilient seismic upstop to keep the piping or equipment at

a fixed elevation during installation. The hangers shall be designed with a release mechanism to free the spring after the installation is complete and the hanger is subjected to its full load. Deflection shall be clearly indicated by means of a scale. Submittals shall include a Drawing of the hanger showing the 30 degree capability. Hangers shall be Type PC30N as manufactured by Mason Industries, Inc.

12. Seismic Cable Restraints shall consist of galvanized steel aircraft cables sized to resist seismic loads with a minimum safety factor of two (2) and arranged to provide all-directional restraint. Cable end connections shall be steel assemblies that swivel to final installation angle and utilize two (2) clamping bolts to provide proper cable engagement. Cables must not be allowed to bend across sharp edges. Cable assemblies shall have an Anchorage Preapproval "R" Number from OSHPD in the State of California verifying the maximum certified load ratings. Cable assemblies shall be Type SCB at the ceiling and at the clevis bolt, SCBH between the hanger rod nut and the clevis or SCBV if clamped to a beam all as manufactured by Mason Industries, Inc.

13. Seismic solid braces shall consist of steel angles or channels to resist seismic loads with a minimum safety factor of 2 and arranged to provide all directional restraint. Seismic solid brace end connectors shall be steel assemblies that swivel to the final installation angle and utilize two through bolts to provide proper attachment. Seismic solid brace assembly shall have anchorage preapproval "R" Number from OSHPD in the state of California verifying the maximum certified load ratings. Solid seismic brace assemblies shall be Type SSB as manufactured by Mason Industries, Inc.

14. Steel angles, sized to prevent buckling, shall be clamped to pipe or equipment rods utilizing a minimum of three ductile iron clamps at each restraint location when required. Welding of support rods is not acceptable. Rod clamp assemblies shall have an Anchorage Preapproval "R" Number from OSHPD in the State of California. Rod clamp assemblies shall be Type SRC as manufactured by Mason Industries, Inc.

15. Pipe clevis cross bolt braces are required in all restraint locations. They shall be special purpose preformed channels deep enough to be held in place by bolts passing over the cross bolt. Clevis cross braces shall have an Anchorage Preapproval "R" Number from OSHPD in the State of California. Clevis cross brace shall be Type CCB as manufactured by Mason Industries, Inc.

16. All-directional seismic snubbers shall consist of interlocking steel members restrained by a one-piece molded neoprene bushing of bridge bearing neoprene. Bushing shall be replaceable and a minimum of 1/4 in. thick. Rated loadings shall not exceed 1000 psi. A minimum air gap of 1/8 in. shall be incorporated in the snubber design in all directions before contact is made between the rigid and resilient surfaces. Snubber end caps shall be removable to allow inspection of internal clearances. Neoprene bushings shall be rotated to insure no short circuits exist before systems are activated. Snubbers shall have an Anchorage Preapproval "R" Number from OSHPD in the State of California verifying the maximum certified horizontal and vertical load ratings. Snubber shall be Type Z-1225 as manufactured by Mason Industries, Inc.

17. All directional seismic snubbers shall consist of interlocking steel members restrained by shock absorbent rubber materials compounded to bridge bearing Specifications. Elastomeric materials shall be replaceable and a minimum of 3/4 in. thick. Rated loadings shall not exceed 1000 psi. Snubbers shall be manufactured with an air gap between hard and resilient material of not less than 1/8 in. nor more that 1/4 in. Snubbers shall be installed with factory set clearances. The capacity of the seismic snubber at 3/8 in. deflection shall be equal or greater than the load assigned to the

mounting grouping controlled by the snubber multiplied by the applicable "G" force. Submittals shall include the load deflection curves up to ½ in. deflection in the x, y and z planes. Snubbers shall have an anchorage preapproval "R" Number from OSHPD in the state of California verifying the maximum certified horizontal and vertical load ratings. Snubbers shall be series Z-1011 as manufactured by Mason Industries, Inc.

18. Stud wedge anchors shall be manufactured from full diameter wire, not from undersized wire that is "rolled up" to create the thread. The stud anchor shall also have a safety shoulder which fully supports the wedge ring under load. The stud anchors shall have an evaluation report number from the I.C.B.O Evaluation Service, Inc. verifying its allowable loads. Drill-in stud wedge anchors shall be Type SAS as manufactured by Mason Industries, Inc.

19. Female wedge anchors are preferred in floor locations so isolators or equipment can be slid into place after the anchors are installed. Anchors shall be manufactured from full diameter wire, and shall have a safety shoulder to fully support the wedge ring under load. Female wedge anchors shall have an evaluation report number from the I.C.B.O Evaluation Service, Inc. verifying to its allowable loads. Drill-in female wedge anchors shall be Type SAB as manufactured by Mason Industries, Inc.

20. Vibration isolation manufacturer shall furnish integral structural steel bases. Rectangular bases are preferred for all equipment. Centrifugal refrigeration machines and pump bases may be T or L shaped where space is a problem. Pump bases for split case pump shall include supports for suction and discharge elbows. All perimeter members shall be steel beams with a minimum depth equal to 1/10 of the longest dimension of the base. Base depth need not exceed 14 in. provided that the deflection and misalignment is kept within acceptable limits as determined by the manufacturer. Height saving brackets shall be employed in all mounting locations to provide a base clearance of 1 in. Bases shall be Type WF as manufactured by Mason Industries, Inc.

21. Vibration isolation manufacturer shall furnish rectangular steel concrete pouring forms for floating and inertia foundations. Bases for split case pumps shall be large enough to provide for suction and discharge elbows. Bases shall be a minimum of 1/12 of the longest dimension of the base but not less than 6 in. The base depth need not exceed 12 in. unless specifically recommended by the base manufacturer for mass or rigidity. Forms shall include minimum concrete reinforcing consisting of ½ in. bars welded in place on 6 in. centers running both ways in a layer 1-1/2 in. above the bottom. Forms shall be furnished with steel templates to hold the anchor bolts sleeves and anchors while concrete is being poured. Height saving brackets shall be employed in all mounting locations to maintain a 1 in. clearance below the base. Wooden formed bases leaving a concrete rather then a steel finish are not acceptable. Base shall be Type BMK or K as manufactured by Mason Industries, Inc.

22. Curb mounted rooftop equipment shall be mounted on spring isolation curbs. The lower member shall consist of a sheet metal Z section containing adjustable and removable steel springs that support the upper floating section. The upper frame must provide continuous support for the equipment and must be captive so as to resiliently resist wind and seismic forces. All directional neoprene snubber bushings shall be a minimum of 1/4 in. thick. Steel springs shall be laterally stable and rest on 1/4 in. thick neoprene acoustical pads. Hardware must be plated and the springs provided with a rust resistant finish. The curbs waterproofing shall consist of a continuous galvanized flexible counter flashing nailed over the lower curbs waterproofing and joined at the corners by EPDM bellows. All spring locations shall have access ports with removable waterproof covers. Lower curbs shall have provision for 2 in. of insulation. The roof curbs shall be built to

seismically contain the rooftop unit. The unit must be solidly fastened to the top floating rail, and the lower Z section anchored to the roof structure. Curb shall have anchorage preapproval "R" from OSHPD in the state of California attesting to the maximum certified horizontal and vertical load ratings. Curb shall be Type RSC as manufactured by Mason Industries, Inc or approved equal.

23. Flexible spherical piping connectors shall employ peroxide cured EPDM in the covers, liners and Dacron tire cord frictioning. Solid steel rings shall be used within the raised face rubber ends to prevent pullout. Flexible cable bead wire is not acceptable. Sizes 2 in. and larger shall have two spheres reinforced with a ring between spheres to maintain shape and complete with split ductile iron or steel flanges with hooked or similar interlocks. Sizes 16 in. to 24 in. may be single sphere. Sizes 3/4 in. to 1-1/2 in. may have threaded bolted flange assemblies, one sphere and cable retention. 14 in. and smaller connectors shall be rated at 250 psi up to 190 F with a uniform drop in allowable pressure to 190 psi at 250 F. 16 in. and larger connectors are rated 180 psi at 190 F and 135 psi at 250 F. Safety factors to burst and flange pullout shall be a minimum of 3/1. All joints must have permanent markings verifying a 5 minute factory test at twice the rated pressure. Concentric reducers to the above Specifications may be substituted for equal ended expansion joints. Pipe connectors shall be installed in piping gaps equal to the length of the expansion joints under pressure. Control rods need only be used in unanchored piping locations where the manufacturer determines the installation exceeds the pressure requirement without control rods, as control rods are not desirable in seismic work. If control rods are used, they must have 1/2 in. thick Neoprene washer bushings large enough in area to take the thrust at 1000 psi maximum on the washer area. Expansion joints shall be installed on the equipment side of the shut off valves.

    Flexible pump connectors shall be installed at each base mounted pump discharge and suction connection. Connections shall be spool type multi-ply stainless steel bellows with tie rods, rated for 150 psig, Keflex type 150.

    Submittals shall include two (2) test reports by independent consultants showing minimum reductions of 20 DB in vibration accelerations and 10 DB in sound pressure levels at typical blade passage frequencies on this or a similar product by the same manufacturer. All expansion joints shall be installed on the equipment side of the shut off valves. Expansion joints shall be SAFEFLEX SFDEJ, SFEJ, SFDCR or SFU and Control Rods CR as manufactured by Mason Industries, Inc.

24. Flexible stainless steel hose shall have stainless steel braid and carbon steel fittings. Sizes 3 in. and larger shall be flanged. Smaller sizes shall have male nipples. Minimum lengths shall be as tabulated:

Flanged	Male Nipples
3 x 1410 x 26	1/2 x 91-1/2 x 13
4 x 1512 x 28	3/4 x 10 2 x 14
5 x 1914 x 30	1 x 112-1/2 x 18
6 x 2016 x 32	1/4 x 12 8 x 22

    Hoses shall be installed on the equipment side of the shut-off valves horizontally and parallel to the equipment shafts wherever possible. Hoses shall be Type BSS as manufactured by Mason Industries, Inc.

25. For vertical riser application more than 3 stories in height, all-directional acoustical pipe anchor, consisting of two sizes of steel tubing separated by a minimum ½ in. thick 60 durometer neoprene. Vertical restraint shall be provided by similar material arranged to

prevent vertical travel in either direction. Allowable loads on the isolation material should not exceed 500 psi and the design shall be balanced for equal resistance in any direction. All-directional anchors shall be Type ADA as manufactured by Mason Industries, Inc.

26. For vertical riser application more than 3 stories in height, pipe guides shall consist of a telescopic arrangement of two sizes of steel tubing separated by a minimum ½ in. thickness of 60 durometer neoprene. The height of the guides shall be preset with a shear pin to allow vertical motion due to pipe expansion or contraction. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of ± 1-5/8 in. motion, or to meet location requirements. Pipe guides shall be Type VSG as manufactured by Mason Industries, Inc.

27. Split Wall Seals consist of two bolted pipe halves with minimum 3/4 in. thick neoprene sponge bonded to the inner faces. The seal shall be tightened around the pipe to eliminate clearance between the inner sponge face and the piping. Concrete may be packed around the seal to make it integral with the floor, wall or ceiling if the seal is not already in place around the pipe prior to the construction of the building member. Seals shall project a minimum of l in. past either face of the wall. Where temperatures exceed 240 deg. F., 10 lb. density fiberglass may be used in lieu of the sponge. Seals shall be Type SWS as manufactured by Mason Industries, Inc.

28. The horizontal thrust restraint shall consist of a spring element in series with a neoprene molded cup as described in Specification 5 with the same deflection as specified for the mountings or hangers. The spring element shall be designed so it can be preset for thrust at the factory and adjusted in the field to allow for a maximum of 1/4 in. movement at start and stop. The assembly shall be furnished with one (1) rod and angle brackets for attachment to both the equipment and the duct work or the equipment and the structure. Horizontal restraints shall be attached at the centerline of thrust and symmetrical on either side of the unit. Horizontal thrust restraints shall be Type WBI/WBD as manufactured by Mason Industries, Inc.

29. At all other platform (no curb) mounted equipment such as condensing units and the like provide 6”x6” neoprene vibration pads at all support points and as shown on the drawings, minimum of six per unit. Pads shall be similar to Mason Industries model #WMFB composite pad of two neoprene layers sandwiching a galvanized steel shim with through hole. Exposed edges of steel shim shall be painted with 2-coats of rustproof primer. Vibration isolators shall be securely bolted to unit and structural support frame with neoprene coated stainless steel bolts, washers and nuts. If required by the equipment manufacturer, provide continuous rail vibration support systems and submit for review and approval.

K. Execution - General:

1. All vibration isolators and seismic restraint systems must be installed in strict accordance with the manufacturers written instructions and all certified submittal data.

2. Installation of vibration isolators and seismic restraints must not cause any change of position of piping resulting in stresses or misalignment.

3. No rigid connections between equipment and the building structure shall be made that degrades the noise and vibration control system herein specified.

4. The Plumbing Contractor shall not install any equipment, piping, duct or conduit which makes rigid connections with the building unless isolation is not specified. "Building" includes, but is not limited to, slabs, beams, columns, studs and walls.

5. Coordinate work with other trades to avoid rigid contact with the building.

6. Any conflicts with other trades which will result in rigid contact with equipment or piping due to inadequate space or other unforeseen conditions should be brought to the architects/engineers attention prior to installation. Corrective work necessitated by conflicts after installation shall be at the responsible Plumbing Subcontractor's expense.

7. Bring to the architects/engineers attention any discrepancies between the Specifications and the field conditions or changes required due to specific equipment selection, prior to installation. Corrective work necessitated by discrepancies after installation shall be at the responsible Plumbing Subcontractor's expense.

8. Correct, at no additional cost, all installations which are deemed defective in workmanship and materials at the Plumbing Subcontractor's expense.

9. Overstressing of the building structure must not occur because of overhead support of equipment. Plumbing Contractor must submit loads to the structural engineer of record for approval. Generally bracing may occur from:

    a. Flanges of structural beams.

    b. Upper truss cords in bar joist construction.

    c. Cast in place inserts or wedge type drill-in concrete anchors.

10. Specification 12 cable restraints shall be installed slightly slack to avoid short circuiting the isolated suspended equipment, piping or conduit.

11. Specification 12 cable assemblies are installed taut on non-isolated systems. Specification 13 seismic solid braces may be used in place of cables on rigidly attached systems only.

12. At locations where Specification 12 or 13 restraints are located, the support rods must be braced when necessary to accept compressive loads with Specification 14 braces.

13. At all locations where Specification 12 or 13 restraints are attached to pipe clevis's, the clevis cross bolt must be reinforced with Specification type 15 braces.

14. Drill-in concrete anchors for ceiling and wall installation shall be Specification type 18, and Specification type 19 female wedge type for floor mounted equipment.

15. Vibration isolation manufacturer shall furnish integral structural steel bases as required. Independent steel rails are not permitted on this project.

16. Hand built elastomeric expansion joints may be used when pipe sizes exceed 24 in. or specified movements exceed Specification 23 capabilities.

17. Where piping passes through walls, floors or ceilings the vibration isolation manufacturer shall provide Specification 27 wall seals.

18. Air handling equipment and centrifugal fans shall be protected against excessive displacement which results from high air thrust in relation to the equipment weight. Horizontal thrust restraint shall be Specification type 28 (see selection guide).

19. Locate isolation hangers as near to the overhead support structure as possible.

L. Vibration Isolation of Piping:

1. Horizontal Pipe Isolation: The first three (3) pipe hangers in the main lines near the mechanical equipment shall be as described in Specification 11. Specification 11 hangers must also be used in all transverse braced isolated locations. Brace hanger rods with SRC clamps Specification 14. Horizontal runs in all other locations throughout the building shall be isolated by hangers as described in Specification 10. Floor supported piping shall rest on isolators as described in Specification 6. Heat exchanger's and expansion tanks are considered part of the piping run. The first three (3) isolators from the isolated equipment will have the same static deflection as specified for the mountings under the connected equipment. If piping is connected to equipment located in basements and hangs from ceilings under occupied spaces the first three hangers shall have 0.75 in. deflection for pipe sizes up to and including 3 in., 1-1/2 in. deflection for pipe sizes up to and including 6 in., and 2-1/2 in. deflection thereafter. Hangers shall be located as close to the overhead structure as practical. Where piping connects to mechanical equipment install Specification 23 flexible piping connection or Specification 24 stainless hoses if 23 is not suitable for the service.

2. Riser Isolation: Risers shall be suspended from Specification 10 hangers or supported by Specification 5 mountings, anchored with Specification 25 anchors, and guided with Specification 26 sliding guides. Steel springs shall be a minimum of 0.75 in. except in those expansion locations where additional deflection is required to limit load changes to ± 25% of the initial load. Submittals must include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on the building structure, spring deflection changes and seismic loads. Submittal data shall include certification that the riser system has been examined for excessive stresses and that none will exist in the proposed design.

M. Seismic Restraint of Piping:

1. Seismically restrain all piping listed as a, b or c below. Use Specification 12 cables if isolated. Specification 12 or 13 restraints may be used on unisolated piping.

   a. Gas piping that is 1 in. I.D. or larger.

   b. Piping located in boiler rooms, mechanical equipment (fan) rooms, and refrigeration equipment rooms that is 1-1/4 in. I.D. and larger.

   c. All other piping 2-1/2 in. diameter and larger.

2. Transverse piping restraints shall be at 40' maximum spacing for all pipe sizes, except where lesser spacing is required to limit anchorage loads.

3. Longitudinal restraints shall be at 80' maximum spacing for all pipe sizes, except where lesser spacing is required to limit anchorage loads.

4. Where thermal expansion is a consideration, guides and anchors may be used as transverse and longitudinal restraints provided they have a capacity equal to or greater than the restraint loads in addition to the loads induced by expansion or contraction.

5. For fuel oil and all gas piping transverse restraints must be at 20 ft. maximum and longitudinal restraints at 40 ft. maximum spacing.

6. Transverse restraint for one (1) pipe section may also act as a longitudinal restraint for a pipe section of the same size connected perpendicular to it if the restraint is installed within 24 in. of the elbow or TEE or combined stresses are within allowable limits at longer distances.

7. Hold down clamps must be used to attach pipe to all trapeze members before applying restraints in a manner similar to clevis supports.

8. Branch lines may not be used to restrain main lines.

9. Cast-iron pipe of all types, glass pipe and any other pipes joined with a four band shield and clamp assembly in Zones 2B, 3 and 4 shall be braced as in sections 3.02.C.2 and 3. For Zones 0, 1 and 2A, 2 band clamps may be used with reduced spacings of ½ of those listed in sections 3.02.C.2 and 3.

N. Seismic Restraint Exclusions:

1. Piping:

a. All piping less than 2-1/2 in. in diameter except those listed below.

b. All gas piping less than 1 in. I.D.

c. All piping in boiler and mechanical equipment rooms less than 1-1/4 in. I.D.

d. All clevis or trapeze supported piping suspended from hanger rods where the point of attachment is less than the 12 in. in length from the structure to the structural connection of the clevis or trapeze.

e. All PVC and fiberglass suspended waste or vent pipe 6 in. in diameter and smaller.

2.45 OIL SEPARATOR (OIL-1)

A. Furnish and install OIL-1, in Outdoor Toilet and Storage Building one floor drain (required due to overhead garage door). Oil separator shall be similar to Watts Drainage OI series recessed epoxy coated steel oil interceptor with gasketed epoxy coated steel skid-proof cover secured with hex head center bolt, double wall deep seal trap, draw-off connection and dual vent connections, integral stainless steel flow control plate, and no-hub connections. Oil separator shall be sized for a flow rate of 20 GPM.

B. Furnish and install Watts model #OI-20-ST Oil Interceptor with Internal Storage. It shall be a recessed epoxy coated steel oil interceptor with internal storage tank, gasketed epoxy coated steel skid-proof cover secured with hex head center bolts, deep seal trap with cleanout, draw-off connection and dual vent connections, sediment bucker, integral stainless steel flow control plate and no hub (standard) connections. The storage tank capacity is 19 gallons and the combined volume for the oil interceptor is 34 gallons. It has 3” inlet and outlet.

C. Alternate to steel oil interceptor: Furnish and install Striem model OS-25, 25-gallon polyethylene oil/sand separator or approved equal. The unit shall have a lifetime guaranteed and made in USA of seamless, rotationally-molded polyethylene. Separator shall be furnished for above or below grade installation, with field adjustable riser system, snap-in flow control and (2) vent connections. Separator flow rate shall be 25 GPM. Separator oil capacity shall be 15 gallons. Sand capacity shall be 6 gallon. Cover shall provide water/gas-tight seal and have a maximum 450 LBS load capacity. It has 3" inlet and outlet.

D. Provide interior oil separator of the type specified above; separator shall be Watts Drainage, Jay R. Smith, Josam, Mifab, Striem or approved equal.

2.46 COMPRESSED AIR SYSTEM ACCESSORIES

A. The proposed air compressor and receiver tank are being furnished by others. The basis of design is a Kaeser model #SM10 Rotary Screw Compressor with integral dryer and air filters which is rated for 45.9 CFM at an operating pressure of 125 PSIG.

B. Plumbing Contractor is responsible for piping the air compressor to the air receiver and then piping the compressed air system loop for the CCL Lab and ETA Shop. The compressed air requirements are for connections at each work bay and several pieces of equipment. This requires quick connect fittings and ball valves for every drop.

C. Connections to the air compressor shall be made with flexible braided stainless steel connector.

D. Provide quick-connect fittings for compressed air equipment connections.

E. Provide Safety Excess Flow Check Valve for compressed air system drops similar to Coilhouse Pneumatics #SV804 ½" pipe size (auto shop) and ¾" pipe size (diesel shop). The safety excess flow check valve is designed to automatically shut off air flow upon a sudden break in the air line, thereby protecting personnel and property from "whipping" air hoses. Allows full unrestricted flow of air while in normal (open) position. Entire unit is corrosion free. It automatically re-sets itself after repair is made. Unit is tamper-proof. Meets OSHA safety regulations.

F. Furnish and install Kimball Midwest or approved vendor 3/8" Push-Button Tru-Flate Female Air Coupler at each compressed air drop location in the ETA Shop with the following specifications: Nitrited steel with composite sleeve material, 175 PSI maximum pressure, 5°F -160°F operating temperature, Tru-Flate style, ¼" NPT. Coordinate with the ETA instructors for exact requirements.

G. Reelcraft model #82100 OLP Heavy Duty Spring Retractable Reels for Air. The hose reel features the following:

1. Hose anti latch-out feature ensures hose retracts every time.
2. Guide arm is field adjustable for wall or ceiling mounting.
3. Dual pedestal base and guide arm design are structurally reinforced.
4. Five-in-one, heat-treated aluminum casting incorporates main shaft, rachet, spring arbor and inlet/outlet plumbing in one-piece casting.
5. Containerized spring assembly provides safer and easier handling during maintenance.
6. Two sealed ball bearings for smooth rotation of main shaft.

2.47 TEMPERATURE MAINTENANCE AND FREEZE PROTECTION HEAT TRACE

A. Furnish and install per manufacturer's instructions, Domestic Hot Water temperature maintenance system as manufactured by Raychem, using HWAT-R2 (208/220v) series for maximum design temperature of 140*f . Cable shall be installed on all non-potable lab hot water, emergency shower tempered and domestic branch hot supply water lines to within three (3) feet of each fixture unless otherwise indicated on drawings. All cable connections shall be made using the factory-supplied RayClic connection.

1. System shall include one (1) HWAT-ECO controller for each circuit as required. Each ECO Controller will require a 30a GFI ground fault protection at the panel supplied by other. Controllers may be interconnected per manufacturer's instructions to provide one master controller for system-wide, simultaneous programming. Cable shall be installed by a licensed plumbing contractor with final electrical connections performed by the electrical subcontractor. System must include pipe insulation installation that follows manufacturer's instructions for correct performance.

Table 5.1 Insulation Thickness

Copper pipe size (in)	IPS insulation size (in)	Insulation thickness (in)
1/2	3/4	1/2
3/4	1	1
1	1 1/4	1
1 1/4	1 1/2	1 1/2
1 1/2	1 1/2	1 1/2
2	2	2

2. Testing for Warranty
   i. Procedure: Measure the heater circuit continuity and the insulation resistance between the braid and the bus wires with a 2500 Vdc megohmmeter (megger).
   ii. Timing: The tests should be performed after the pipe insulation has been installed and prior to the installation of wall or ceiling panels, and shall be witnessed by the Construction Manager and the manufacturer or the manufacturer's representative.
   iii. Acceptable results: The heater circuit shall be continuous and megger readings shall be at least 1000 megohm regardless of the heater length. Circuits yielding unacceptable readings must be repaired or replaced.
   iv. Submittal of results: Submit records of the test data to the Construction Manager. Self-regulating heating cables and components to have a limited 10-year warranty extension from the date of installation if a properly completed online warranty form is completed within 30 days from the date of installation.

B. Grease Waste Line Flow Maintenance (Metal Pipe) Heat Trace

1. Furnish and install on locations shown on plans, Raychem XL-Trace self-regulating freeze protection cable. System shall include cable with modified fluoropolymer (-CT) outer jacket. Rayclic series system connectors, splices, tees and Type LE, lighted end caps for visual system-on confirmation.
2. System to include a series C910 controller/monitor for each circuit. Controller shall include one thermal input located on pipe under insulation to maintain a set point of 110*f.
3. Contractor to coordinate with electrical contractor to verify correct voltage and amperage for power panel breaker. Ground Fault protection to be provided internally by the C910.
4. Contractor to verify installation by documenting sequential testing of each cable section during assembly before and after installing the thermal insulation by subjecting heating

cable to testing using a 2500-Vdc Megger, Minimum insulation resistance shall be 20 megohms or greater.

5. The heating cable for grease line flow maintenance shall be as indicated on plans (and confirmed by rep) to maintain line temp of 110*f. The required heating cable output rating is in watts per foot at 50°F. (Heating cable selection based on 1 inch fiberglass insulation on metal piping.)

C. Roof and Gutter De-Icing System Specification for Storm Drain piping outside of building envelope (at three (3) locations: main floor entrance canopy, main floor loading dock canopy, second floor roof canopy outside of Vestibule D210.1).

1. Heating Cable – Raychem IceStop GM-2XT self-regulating heating cable with fluoropolymer (-XT) outer jacket. The heating cable shall operate on line voltages of 277 volts without the use of transformers. The heating cable power output shall be 12 W/ft at 32°F in ice or snow.
2. Connection Kits – Raychem RayClic connection kits and accessories.
3. Roof clips – Used to secure IceStop heating cables to roofs and gutters. The clips may be attached with mechanical fasteners (screws or nails) on shake roofs or using adhesive on metal, slate or composite roofing. (PTM Catalog Number: GMK-RC).
4. Downspout Hangers - Used to provide mechanical protection and strain relief to the IceStop heating cable as it goes over sharp edges and to hold the heating cable in place at the top of downspouts. (PTM Catalog Number: GMK-RAKE).
5. Control – Digitrace ECW-GF shall provide 30mA ground fault protection and control of the system based on ambient temperature.
6. Installation – Install and secure the heating cable in accordance with the IceStop System Installation and Operation Manual (H58067). See project drawings for specific layout and installation details.
7. Testing –The heating cable circuit integrity shall be tested using a 2500 Vdc megohmmeter. Minimum acceptable insulation resistance shall be 1000 megohms.
8. Start-up – Start-up of system shall be performed by factory technician or factory representative per the owner's requirements.
9. Contractor shall submit to owner results of installation tests required by the manufacturer.
10. Manufacturer shall provide ten (10) year limited warranty for GM-2XT heating cables and components. Provide one (1) year warranty for all heat trace controllers.
11. For questions and coordination contact Patrick Shea at Emerson Swan. Email: pshea@emersonswan.com / cell: 508-415-7510.

2.48 TRIPLEX VARIABLE SPEED DOMESTIC WATER BOOSTER PUMP SYSTEM – PACKAGED (BP-1)

A. GENERAL

1. WORK INCLUDED

a. Variable Speed Packaged Pumping System

2. REFERENCE STANDARDS: The work in this section is subject to the requirements of applicable portions of the following standards:

a. Hydraulic Institute

b. ANSI – American National Standards Institute
c. ASTM – American Society for Testing and Materials
d. IEEE – Institute of Electrical and Electronics Engineers
e. NEMA – National Electrical Manufacturers Association
f. NEC – National Electrical Code
g. ISO – International Standards Organization
h. UL – Underwriters Laboratories, Inc.

B. PRODUCTS

1. VARIABLE SPEED PACKAGED PUMPING SYSTEM

a. Furnish and install a pre-fabricated and tested variable speed packaged pumping system to maintain constant water delivery pressure.

b. The packaged pump system shall be a standard product of a single pump manufacturer. The entire pump system including pumps and pump logic controller, shall be designed, built, and tested by the same manufacturer.

c. The complete packaged water booster pump system shall be certified and listed by UL (Category QCZJ – Packaged Pumping Systems) for conformance to U.S. and Canadian Standards.

d. The complete packaged pumping system shall be NSF61 / NSF372 Listed for drinking water and low lead requirements.

e. The packaged pump system shall be ASHRAE 90.1 – 2010 compliant without the need of a remote mounted sensor. The control logic used to simulate a remote mounted sensor shall be proportional pressure control with squared or linear adaptation. An actual flow rate or calculated flow rate based on performance curves (5^{th} order polynomial) loaded into the controller; shall be used to adjust setpoint pressure in proportional pressure control.

2. PUMPS

a. All pumps shall be ANSI NSF 61 / NSF372 Listed for drinking water and low lead requirements

b. The pumps shall be of the in-line vertical multi-stage design.

c. The head-capacity curve shall have a steady rise in head from maximum to minimum flow within the preferred operating region. The shut-off head shall be a minimum of 20% higher than the head at the best efficiency point.

d. Large (CR32 to CR155) In-line Vertical Multi-Stage Pumps (Nominal flows from 130 to 1070 gallons per minute) shall have the following features:

i. The pump impellers shall be secured directly to the smooth pump shaft by means of a split cone and nut design.

ii. The suction/discharge base shall have ANSI Class 125 or Class 250 flange connections in a slip ring (rotating flange) design as indicated in the drawings or pump schedule.

iii. Pump Construction.

a. Suction/discharge base, pump head	Ductile Iron (ASTM 70-50-05)
b. Shaft couplings, flange rings:	Ductile Iron (ASTM 70-50-05)
b. Shaft	431 Stainless Steel
c. Motor Stool	Cast Iron (ASTM Class 30)
d. Impellers, diffuser chambers, outer sleeve:	304 Stainless Steel
e. Impeller wear rings:	304 Stainless Steel
f. Intermediate Bearing Journals:	Silicon Carbide
g. Intermediate Chamber Bearings:	Leadless Tin Bronze
h. Chamber Bushings:	Graphite Filled PTFE
I. O-rings:	EPDM

Optional materials for the suction/discharge base and pump head shall be cast 316 stainless steel (ASTM CF-8M) resulting in all wetted parts of stainless steel.

iv. The shaft seal shall be a balanced O-ring cartridge type with the following features:

a. Collar, Drivers, Spring:	316 Stainless Steel
b. Shaft Sleeve, Gland Plate:	316 Stainless Steel
c. Stationary Ring:	Graphite embedded Silicon Carbide
d. Rotating Ring:	Graphite embedded Silicon Carbide
e. O-rings:	EPDM

v. Shaft seal replacement shall be possible without removal of any pump components other than the coupling guard, motor couplings, motor and seal cover. The entire cartridge shaft seal shall be removable as a one-piece component.

vi. Pumps with motors equal to or larger than 15 hp (fifteen horsepower) shall have adequate space within the motor stool so that shaft seal replacement is possible without motor removal.

C. INTEGRATED VARIABLE FREQUENCY DRIVE MOTORS

1. Efficiency: The motors shall be of permanent magnet design meeting IE5 efficiency levels where the combined motor and VFD efficiency exceed NEMA Premium Efficiency standards.

2. Bearing Current Mitigation: Motors shall use WSB (Winding Set Back) and/or CHS (Coil Head Shield) designs that reduce the Bearing Voltage Ratio (BVR) far enough to eliminate damaging bearing currents. Shaft grounding rings/brushes or common mode filters shall not be required.

3. Motor Enclosure/Cooling: The motor shall be Totally Enclosed Fan Cooled (TEFC) with a standard NEMA C-Face with Class F insulation and a temperature rise class no higher than Class B. The cooling design of the motor and VFD shall be such that a Class B motor temperature rise is not exceeded at full rated load and speed at a minimum switching frequency of 9.0 kHz.

4. The power and control electronics shall be housed in a UL Type 3 enclosure and the combined motor/VFD rating shall be IP55 (protection against dust and nozzle directed water from any direction).

5. The VFD shall be of the PWM (Pulse Width Modulation) design using IGBT (Insulated Gate Bipolar Transistor) technology.

6. The VFD shall convert incoming fixed frequency three-phase AC power into a variable frequency and voltage for controlling the speed of motor. The motor current shall closely approximate a sine wave. Motor voltage shall be varied with frequency to maintain desired motor current suitable for centrifugal pump control and to eliminate the need for motor de-rating.

7. The VFD shall automatically reduce the switching frequency and/or the output voltage and frequency to the motor during periods of sustained ambient temperatures that are higher than the normal operating range. The switching frequency shall be reduced before motor speed is reduced.

8. An integral RFI filter shall be standard in the VFD.

9. The VFD shall have a minimum of two skip frequency bands which can be field adjustable.

10. The VFD shall have internal solid-state overload protection designed to trip within the range of 105-110% of rated current.

11. The integrated VFD motor shall include protection against input transients, phase imbalance, loss of AC line phase, over-voltage, under-voltage, VFD over-temperature, and motor over- temperature. Three-phase integrated VFD motors shall be capable of providing full output voltage and frequency with a voltage imbalance of up to 10%.

12. The integrated VFD motor shall have, as a minimum, the following input/output capabilities:

    a. Speed Reference Signal: 0-10 VDC, 4-20mA
    b. Digital remote on/off
    c. Fault Signal Relay (NC or NO)
    d. Fieldbus communication port (RS485)

13. Motor drive end bearings shall be adequately sized so that the minimum L10 bearing life is 20,000 hours at the minimum allowable continuous flow rate for the pump at full rated speed.

D. PUMP SYSTEM CONTROLLER

1. The pump system controller shall be a standard product developed and supported by the pump manufacturer.

2. The controller shall be microprocessor based capable of having software changes and updates via personal computer (notebook). The controller user interface shall have a color display with a minimum screen size of 3-1/2” x 4-5/8” for easy viewing of system

status parameters and for field programming. The display shall have a back light with contrast adjustment. Password protection of system settings shall be standard.

3. Galvanic Isolation: The controller shall provide internal galvanic isolation to all digital and analog inputs as well as all fieldbus connections.

4. Backup Battery: The controller shall have the ability to be connected to a backup battery to supply power to the controller during periods of loss of supply power.

5. Home Status Screen: The controller shall display the following as status readings from a single display on the controller (this display shall be the default):

   a. Current value of the control parameter, (typically differential pressure)
   b. Most recent existing alarm (if any)
   c. System status with current operating mode
   d. Status of each pump with current operating mode and rotational speed as a percentage (%)
   e. Estimated flow-rate, (or actual flow if flow sensor is used)
   f. One user defined measured parameter (i.e. power consumption)

6. Inputs/Outputs: The controller shall have as a minimum the following hardware inputs and outputs:

   a. Three analog inputs (4-20mA or 0-10VDC)
   b. Three digital inputs
   c. Two digital outputs
   d. Ethernet connection (built-in web server)
   e. Field Service connection to PC for advanced programming, software and/or firmware upgrades and data logging

7. Pump system programming: As a minimum, the following parameters shall be available and/or field adjustable:
   a. Sensor Settings: Suction, Discharge, Differential Pressure [analog supply/range]
   b. PI Controller: Proportional gain (Kp) and Integral time (Ti)
   c. Low suction: Pressure/level shutdown via digital contact
   d. Limit Exceeding function: For low system, low suction warnings and shut down [via analog input]
   e. Flow meter settings (if used, analog signal)

8. Pump Curve Data: The actual pump performance curves (5^{th} order polynomial) shall be loaded (software) into the pump system controller. Pump curve data shall be used for the following:

   a. Display and data logging of calculated flow rate
   b. Variable pressure control (quadratic or proportional)
   c. Pump outside of duty range protection
   d. Sequence pumps based on efficiency

9. Variable Pressure Control: The controller shall have variable pressure control to compensate for pipe friction loss by decreasing the pressure set-point at lower flow-rates and increasing the pressure set-point at higher flow-rates by using the actual flow rate or calculated flow rate. Variable pressure control that uses power consumption and speed

only shall not be considered equal to variable pressure control that uses actual differential pressure measurement along with pump power and speed.

10. Multi-Sensor: The controller shall be able to control using up to six differential pressure (DP) sensors (zones). Each zone shall have a programmable maximum and minimum DP range. The controller shall be capable of an energy optimal mode where pump speed/energy shall be reduced until any of the zones reach the minimum DP setting.

11. Check Valve Failure Detection (Systems with integrated VFD motors): The system controller shall be able to detect motors turning in the opposite direction and give check valve failure notification.

    a. For minor leaks the pump shall start with a warning indicated
    b. For major leaks the pump shall remain off to prevent damage with an alarm indication

12. Pulse flow meter: The system controller shall be able to receive pulse readings from a digital pulse meter and log/display accumulated flow.

13. DP Subtraction: The system controller shall be able to control off subtraction of two pressure or temperature sensors for differential pressure or differential temperature control.

14. Programmable Setpoints: The system controller shall be able to accept up to seven programmable set-points via a digital input, (additional input/output module may be required).

15. Setpoint Influence: The system pressure set-point shall be capable of being automatically adjusted by using an external set-point influence. The set-point influence function enables the user to adjust the control parameter (typically differential pressure) by measuring an additional parameter. (Example: Lower the system differential pressure set-point based on a flow or outdoor temperature measurement).

16. Remote Control: The controller shall be capable of receiving a remote analog set-point (4-20mA or 0-10 VDC) as well as a remote system on/off (digital) signal.

17. Setpoint Ramp: The controller shall be able to adjust the ramp time of a change in set point (increase and decrease).

18. Warnings and Alarms: The pump system controller shall store up to 24 warnings and alarms in memory. The time, date and duration of each alarm shall be recorded. A potential-free relay shall be provided for alarm notification to the building management system. The controller shall display the following alarm conditions:

Individual pump failure	Check valve failure
VFD trip/failure	Loss of sensor signal (4-20 mA)
Loss of remote set-point signal (4-20mA)	External Fault
Pump outside of duty range	Limit 1 and 2 exceeded*

    *The controller shall be capable of monitoring two analog signals (i.e. suction pressure and discharge pressure) for additional pump or system protection.

19. Built-in data log: The controller shall have built-in data logging capability. Logged values shall be graphically displayed on the controller and shall be downloadable to a

notebook/pc as a delimited text file. A minimum of 7200 samples per logged value shall be available for the following parameters:

a. Estimated flow-rate (or actual flow if flow sensor is connected)
b. Speed of pumps
c. Process Value/sensor feedback (usually differential pressure)
d. Power consumption
e. Controlling parameter (setpoint)
f. Inlet pressure (when remote differential pressure is the primary sensor)

20. Redundant Primary Sensor: The controller shall be capable of receiving a redundant sensor input to function as a backup to the primary sensor.

21. Secondary Sensor: Upon loss of signal from the remote sensor, the controller shall be capable of reverting control to the pump system mounted sensors with a programmable setpoint. The pumps shall maintain a constant, proportional or quadratic pressure across the system until the remote setpoint signal is restored.

22. Pump Test: The controller shall have a pump “Test Run” feature such that pumps are switched on during periods of inactivity (system is switched to the “off” position but with electricity supply still connected). The inoperative pumps shall be switched on for a period of three to four seconds every 24 hours, 48 hours or once per week and at a programmable time of day.

23. Reduced Operation: During backup generator operation, the controller shall be capable of reducing the power consumed by the pump system by either limiting the number of pumps in operation or by limiting the amount of power consumption (kW). The controller shall receive a digital input indicating backup generator operation.

24. Power and Energy Consumption: The controller shall be capable of displaying instantaneous power consumption (Watts or kilowatts) and cumulative energy consumption (kilowatt-hours).

25. Specific Energy: When a flow sensor is connected, the controller shall be capable of displaying instantaneous specific energy in Watt-hours per gallon (Wh/gal) or Watt-hours per 1,000 gallons (Wh/kgal).

26. Built-in Ethernet: The controller shall have an Ethernet connection with a built-in web server allowing for connection to a building computer network with read/write access to the controller via a web browser.

27. Service Contact Information: The controller shall have a programmable Service Contact Field that can be populated with service contact information including: contact name, address, phone number(s) and website.

E. CONTROL PANEL

SCCR: The complete control panel assembly shall have a Short Circuit Current Rating of 100 kA

BMS Integration: Standard shall be BACnet MS/TP
*Other protocols available: BACnet IP, Ethernet IP, Modbus RTU, Modbus TCP, LON

The pump system controller shall be mounted in a UL Type 3R rated enclosure. A self-certified NEMA enclosure rating shall not be considered equal. The entire UL Type 3R control panel shall be UL 508 listed as an assembly. The control panel shall include a main disconnect, circuit breakers for each pump and the control circuit and control relays for alarm functions. The control panel shall include the following:

80 dB System Fault Audible Alarm with push button to silence Emergency/Normal Operation Switches (Control bypass)
Individual Service Disconnect Switches (accessible outside of panel)
Pump Run Lights
System Fault Light
Surge Arrestor

F. SEQUENCE OF OPERATION

1. The system controller shall operate equal capacity variable speed pumps to maintain a constant differential pressure (system set-point from remote DP sensor) or proportional pressure differential pressure setpoint (system setpoint from local mounted sensor(s)), depending on the application. The system controller shall receive an analog signal [4-20mA] from the factory installed pressure transducer on the discharge and suction manifolds, indicating the actual system pressure and inlet pressure. The controller shall be capable of controlling off the subtraction of discharge minus suction transducers for differential pressure across the manifolds.

   Standard Cascade Control (Pumping Efficiency Based):
   The pump system controller shall adjust pump speed as necessary to maintain system set-point pressure as flow demand increases. Utilizing the pump curve information (5^{th} order polynomial), the pump system controller shall stage on additional pumps when pump hydraulic efficiency will be higher with additional pumps in operation. Exception: When the flow and head are outside the operating pump(s) allowable operating range the controller shall switch on an additional pump thus distributing flow and allowing all pump(s) to operate in allowable operating range. When the system pressure is equal to the system set-point, all pumps in operation shall reach equal operating speeds. The pump system controller shall have field adjustable Proportional Gain and Integral time (PI) settings for system optimization.

   Optional Cascade Control (Pump Start Speed Based):
   As flow demand increases the pump speed shall be increased to maintain the system set-point pressure. When the operating pump(s) reach 96% of full speed (adjustable), an additional pump will be started and will increase speed until the system set-point is achieved. When the system pressure is equal to the system set-point all pumps in operation shall reach equal operating speeds. The pump system controller shall have field adjustable Proportional Gain and Integral time (PI) settings for system optimization.

2. The system controller shall be capable of switching pumps on and off to satisfy system demand without the use of flow switches, motor current monitors or temperature measuring devices.

3. All pumps in the system shall alternate automatically based on demand, time and fault. If flow demand is continuous (no flow shut-down does not occur), the system controller

shall have the capability to alternate the pumps every 24 hours, every 48 hours or once per week. The interval and actual time of the pump change-over shall be field adjustable.

4. The system controller shall be able to control a pressure maintenance pump, (jockey pump), in the system in pressure boosting applications. The set point of the pressure maintenance pump shall be able to be any value above or below the pump system's set point. The pressure maintenance pump shall be able to be staged on as back-up pump when capacity of pump system is exceeded.

G. LOW FLOW STOP FUNCTION (Constant Pressure Applications)

The system controller shall be capable of stopping pumps during periods of low-flow or zero-flow without wasting water or adding unwanted heat to the liquid. Temperature based no flow shut- down methods that have the potential to waste water and add unwanted temperature rise to the pumping fluid are not acceptable and shall not be used.

Standard Low Flow Stop and Energy Saving Mode
If a low or no flow shut-down is required (periods of low or zero demand) a bladder type diaphragm tank shall be installed with a pre-charge pressure of 70% of system set-point. The tank shall be piped to the discharge manifold or system piping downstream of the pump system. When only one pump is in operation the system controller shall be capable of detecting low flow (less than 10% of pump nominal flow) without the use of additional flow sensing devices. When a low flow is detected, the system controller shall increase pump speed until the discharge pressure reaches the stop pressure (system set-point plus 50% of programmed on/off band, adjustable). The pump shall remain off until the discharge pressure reaches the start pressure (system set- point minus 50% of programmed on/off band, adjustable). Upon low flow shut-down a pump shall be restarted in one of the following two ways:

1. Low Flow Restart: If the low flow condition still exists, the pump shall start and the speed shall again be increased until the stop pressure is reached and the pump shall again be switched off.

2. Normal Flow Restart: If the pump system controller determines a low flow condition no longer exists the pump shall start and the speed shall be increased until the system pressure reaches the system set-point.

H. SYSTEM CONSTRUCTION

1. Suction and discharge manifold construction shall be in way that ensures minimal pressure drops, minimize potential for corrosion, and prevents bacteria growth at intersection of piping into the manifold. Manifold construction that includes sharp edge transitions or interconnecting piping protruding into manifold is not acceptable. Manifold construction shall be such that water stagnation cannot exist in manifold during operation to prevent bacteria growth inside manifold.

2. The suction and discharge manifolds material shall be 316 stainless steel. Manifold connection sizes shall be as follows:

3 inch and smaller:	Male NPT threaded
4 inch through 8 inch:	ANSI Class 150 rotating flanges
10 inch and larger:	ANSI Class 150 flanges

3. Pump Isolation valves shall be provided on the suction and discharge of each pump. Isolation valve sizes 2 inch and smaller shall be nickel plated brass full port ball valves. Isolation valve sizes 3 inch and larger shall be a full lug style butterfly valve. The valve disk shall be of stainless steel. The valve seat material shall be EPDM and the body shall be cast iron, coated internally and externally with fusion-bonded epoxy.

4. A spring-loaded non-slam type check valve shall be installed on the discharge of each pump. The valve shall be a wafer style type fitted between two flanges. The head loss through the check valve shall not exceed 5 psi at the pump design capacity. Check valves 1-1/2" and smaller shall have a POM composite body and poppet, a stainless steel spring with EPDM or NBR seats. Check valves 2" and larger shall have a body material of stainless steel or epoxy coated iron (fusion bonded) with an EPDM or NBR resilient seat. Spring material shall be stainless steel. Disk shall be of stainless steel or leadless bronze.

5. For systems that require a diaphragm tank, a connection of no smaller than ¾" shall be provided on the discharge manifold.

6. A pressure transducer shall be factory installed on the discharge manifold (or field installed as specified on plans). Systems with positive inlet gauge pressure shall have a factory installed pressure transducer on the suction manifold for water shortage protection. Pressure transducers shall be made of 316 stainless steel. Transducer accuracy shall be +/- 1.0% full scale with hysteresis and repeatability of no greater than 0.1% full scale. The output signal shall be 4-20 mA with a supply voltage range of 9-32 VDC.

7. A bourdon tube pressure gauge, 2.5 inch diameter, shall be placed on the suction and discharge manifolds. The gauge shall be liquid filled and have copper alloy internal parts in a stainless steel case. Gauge accuracy shall be 2/1/2 %. The gauge shall be capable of a pressure of 30% above its maximum span without requiring recalibration.

8. Systems with a flooded suction inlet or suction lift configuration shall have a factory installed water shortage protection device on the suction manifold.

9. The base frame shall be constructed of corrosion resistant 304 stainless steel for systems with CR pump sizes up to CR64. The pump system base shall be powder coated white aluminum RAL9006, carbon steel ASTM A36 structural steel, for systems with CR95 and larger pumps.

10. Rubber vibration dampeners shall be fitted between each pumps and base frame to minimize vibration.

11. Depending on the system size and configuration, the control panel shall be mounted in one of the following ways:

    On a 304 stainless steel fabricated control cabinet stand attached to the system skid.
    On a 304 stainless steel fabricated skid, separate from the main system skid
    On its own base (floor mounted with plinth)

I. TESTING

1. The tester used for testing the pump system shall be constructed and calibrated according to the requirements of hydraulic test standard ISO 9906.

2. The entire pump station shall as a minimum be factory tested for functionality and documented results of functionality test supplied with pump station.

   Functionality testing shall include the following parameters:

   a. Complete System Hydrostatic Test – 1.5 times the nameplate maximum pressure
   b. No-Flow Detection Shutoff Test
   c. Water Shortage Test
   d. Two-Point Setpoint Performance Test.

3. Water used for testing shall be treated with three different filtration systems to ensure only clean water is used for testing pump station.
   a. 25 micron mechanical filter – removes solid parts from water
   b. Activated carbon filter – keeps water clear and eliminates odor
   c. Ultraviolet light system – kills all bacteria growth

4. Optional performance testing shall include:
   a. Witnessed Verified Performance Test

J. WARRANTY

1. The warranty period shall be a non-prorated period of 24 months from date of installation, not to exceed 30 months from date of manufacture.

K. PRESSURE BOOSTER EXPANSION TANK

1. Furnish and install, as shown on plans, a 106 gallon, 30”Ø x 49” tall precharged steel water wall and pressure booster expansion tank with replaceable heavy-duty butyl bladder. The tanks shall have NPT epoxy lines system connection and a 0.302”-32 charging valve connection (standard tire valve) to facilitate the on-site charging of the tank to meet system requirements, a pressure gauge, and bladder integrity monitor. The tank must be constructed in accordance with most recent addendum of Section VIII Division 1 of the ASME Boiler and Pressure Vessel Code. Products comply with NSF/ANSI Standard 61. Tank shall be Grundfos model #GFXA-400 or approved equal.

2. Tanks needs to be charged on-site to 70% of system design pressure.

2.49 ALTERNATE pH NEUTRALIZATION SYSTEM (DUAL TREATMENT NEUTRALIZATION SYSTEM)

A. Acid chemical dual–stage, active & passive, neutralization / dilution system shall be Method #2C to include limestone treatment and chemical feed/mixing back-up, as manufactured by Town & Country Plastics, LLC with single source responsibility for this entire system. System shall be complete as shown on the drawings and per manufacturers instructors and shall consist of the following:

B. Tank #1 (Limestone Neutralization/Dilution): T&C Plastics model #NT-325, with diameter: 36” by height: 74”. This tank shall be constructed of molded, seamless High Density Polyethylene (HDPE) conforming to ASTM Specification D-#1248 latest edition and shall have necessary inlet, outlet and vent connections. All connections shall be same size, unless vent is smaller. Tank shall be complete with matching heavy-duty, reinforced bolted cover with Neoprene gasket and necessary bolts, nuts and washers. 100 gallon tanks and larger shall have ½” thick × 3” high reinforcing bars welded underneath the cover. 1,200 gallon and larger tanks

shall have primed steel bands around the outside of the tank walls for extra strength. Inlet shall have internal elbow and dip tube in order to form a deep seal, unless local code requires it differently (such as the state of Ohio, city of White Plains, etc.). Internal HDPE bracing to tank wall shall be done by plastic welding on the longer dip tubes.

C. Tank #2 (Mixing and Finishing): To be same as above Tank #1, T&C Plastics model #NT-325, with Diameter: 36" by Height: 74". Also, tank #2 to have 6" vertical mixer flanged connection with gasketed blind flange to prevent fume leakage and 3" gasketed, flanged pH probe inlet and support assembly connection and two 1" chemicals (acid & caustic) feed connections in tank sidewall.

D. Sampling Tank #3: T&C Plastics model #NT-5M. This molded HighDensity Polyethylene (HDPE) tank (approx. 11" diameter by 14" high I. D.) shall have the same size inlet and outlet (no vent) connections as the tanks above. This tank cover will have another final 3" gasketed, flanged pH probe inlet and support assembly in cover. This tank shall be supported by a steel stand or concrete blocks, as furnished and installed by contractor. Stand shall be epoxy painted by contractor. Cover to be ½" thick to support probe assembly.

E. Tank #4 (Acid Feed Tank/Drum): T&C Plastics model #D-55M. This drum tank shall be molded of High-Density Polyethylene (HDPE) and shall be standard 55-gallon size. Tank shall have one 2" threaded fill connection, one 2" threaded vent connection and one 1" threaded drain connection and one 1 ¼" threaded connection for low level float assembly (for alarms). Contractor to furnish and install necessary acid solution prior to job completion.

F. Tank #5 (Caustic/Alkali Feed Tank/Drum): T&C Plastics model #D55M. This drum tank shall be the same as Tank #4, but contractor shall furnish necessary caustic / alkali solution, prior to job completion.

G. Agitator (Mixer): Mixer shall be T&C series "F" direct drive for vertical mounting through tank cover; 1/3 horse power, 120V, single phase, 60 cycle 1750 RPM. Shaft and propeller shall be constructed of type #316 stainless steel. Contractor to furnish and install strong metal bracket to give extra support to mixer/agitator (epoxy painted), to wall or ceiling. Mixer shaft length shall terminate about half way up to outlet centerline. Signal to mixer power starter relay to be a solid 4amp signal from control panel contacts.

H. Low Liquid Level Alarm Assemblies: Two (2) T & C model #PP-44T low liquid level floats & alarm assemblies shall be constructed of Polypropylene (PP) and shall include a light and horn alarm. These units are independent of the control panel below. Each assembly to come with switch box, pilot (running) light, alarm light, buzzer and transformer with contacts.

I. pH Monitoring, Recording and Alarm Systems: One T&C Model #K100AM2 control panel with two (2) probe assemblies, shall be furnished. System includes two (2) immersion type continuous monitoring electrode assemblies with submersible electrode holders, reference measuring and temperature compensating pH electrodes and junction box relays. One pH electrode assembly housing to be installed into sampling tank #3 for recording the effluent discharges and second pH probe assembly to be installed into chemical feed and mixing tank #2 for controlling back-up chemical treatment of effluent (if limestone does not completely reduce the effluent to an acceptable pH level). pH control panel to be wall mounted, NEMA #12 NEMA #4 HDPE or steel panel finished with epoxy paint, prewired and panel shall contain the following components: pH strip chart recorder for approximately one month continuous recording; audible/visual alarms with horn and red alarm lights; panel shall indicate by additional lights, when effluent is below or above, low and high pH set points; audible silencing and push button silencing relay; power fuse to prevent power surge damage; visual pH meter (from 014) with signal impulse amplifier, high and low pH points and

additional alarm contacts; course & fine tune adjustment knobs for superior analog meter (digital not acceptable) to track pH movement and additional similar knobs for adjusting pH recorder; unit to included up to ten (10) feet of pH wiring cable for hook-ups from each tank probe assembly to the pH control panel. Contractor to furnish any low amperage secondary wiring relays and in-line fuses necessary to wire mixer and pumps or valves from control panel. Contractor to run electric wiring and pH cables inside conduit. Contractor to also furnish electric power wiring and power supply for the pH control panel. Panel to have coarse and fine tuning adjustments, as well as temperature tuning. (Note: If pH cables are to be run underground or in walls, they should be run through 1" minimum PVC electrical conduits.)

J. Chemical Feed Pumps: Contractor to furnish and install two (2) chemical feed pumps. T&C Model #BC-2CP-MD pumps shall be 115 volts, single phase, 60 cycle and all wetted parts shall be made of polypropylene (PP). Pumps to be magnetic drive, centrifugal type for superior service and non -contact of internal moving pump parts. Pumps to operate via power starter relays, using solid 4 amp signals from control panel (to turn power on and off as needed, through power starter relays). Variable milliamp signals are not acceptable, even with shielded cables.

K. Chemical Feed Piping: Contractor shall install T&C ½" & ¾" polypropylene (PP) schedule 80 threaded pipes, fittings, unions and valves from acid feed and caustic feed drum tanks to the two (2) PP chemical feed pumps and then to tank #2, (mixing & finishing tanks). All threaded connections shall be adequately sealed with sufficient Teflon tape. See details on how to hook up pumps to drum tanks.

L. Limestone Chips: Contractor to supply proper limestone chips (1" to 3" diam.) containing at least 90% calcium carbonate and be a random mixture from 1" to 3" size, for tank #1. Contractor shall furnish three tank fillings total of limestone chips for tank #1 (one for initial fill and two more for additional fills, for maintenance purposes, given to owner, for later use). Contractor shall fill tank #1 with water first and gently put limestone into tank #1 (as not to damage tank, top gasketing or fittings), up to the bottom (invert) of the outlet connection.

M. Special Warning/Maintenance Signs: Provide signs stenciled in black letters, 1" high on acrylic plastic backgrounds. Signs shall read:

Model # WMS-1 SIGN: APPROX. 16" HIGH × 32" LONG

"IMPORTANT - BASIN MUST BE INSPECTED FREQUENTLY AND NEUTRALIZING AGENT REPLACED WHEN NECESSARY. FAILURE TO DO SO MAY RESULT IN SERIOUS DAMAGE TO PIPING SYSTEMS.

DATE LAST INSPECTED_____"

Model # WMS-2 SIGN: APPROX. 10" HIGH × 20" LONG

"IMPORTANT - ALWAYS WEAR EYE PROTECTIVE GEAR, RUBBER GLOVES AND CARBON FILTER MASK WHEN RECHARGING THE TANK WITH LIMESTONE CHIPS.

FURTHER INFORMATION CONTACT: Town & Country Plastics, LLC"

N. Start-up Training, Instruction & Calibration: T&C to provide the services of an authorized manufacturer's representative and/or factory-trained technician to check installation of equipment into operation and train local operation personnel in the maintenance and operations procedures. The amount of time required for this shall not exceed one business

day's labor. Contractor shall install all equipment and components in accordance with Manufacturers recommendation prior to this factory service.

O. Leak Detection Float Assemblies with Containment Tank(s): If tanks are installed in a sealed concrete pit, below ground, a Model #PP44T polypropylene leak detection float is to be mounted on bottom of pit floor. The electrical switch box with operational (pilot) light, alarm light, chrome buzzer and transformer, shall be mounted by the electrical subcontractor; who shall provide 115V, single phase, 60Hertz power and necessary conduits from switch box/transformer to leak detection float assembly.

P. EXTRAS BY OTHERS:
   1. TANK STEEL STAND (EPOXY COATED) OR CONCRETE BLACK FOR SUPPORTING SAMPLING TANK.
   2. SUPPORT BRACKET (EPOXY COATED) FOR MIXER.
   3. CHEMICALS FOR TANKS #4 AND #5.
   4. SECONDARY WIRING CONDUITS AND THREE POWER STARTER RELAYS TO MIXER AND TWO PUMPS
   5. INTERCONNECTING PIPING, ADAPTERS AND FITTINGS. (ALSO, IF FLANGES USED, THEN BOLTS NUTS & WASHERS AND GASKETS.)
   6. CONTRACTOR SHALL VIDEO TAPE STARTUP INSTRUCTIONAL TRAINING AND GIVE COPY TO OWNER'S REPRESENTATIVE.

Q. Operations & Maintenance Manuals and Perishables: Manufacturer shall furnish operation and maintenance manuals to be given to contractor (for turning over to owner), prior to system startup, training and calibration, which should take place when system is ready for operation, by owner. System perishables are monthly inkless chart papers, limestone chips and pH electrodes.

R. Safety Ventilation and Safety Equipment: Entire system shall be sealed to prevent fumes from entering room. Tanks shall be appropriately vented, as shown on drawings and mentioned above. Tanks # 4 and # 5 shall be tied into the acid waste vent stack(s), just like tanks # 1 and # 2. However, tanks # 4 and # 5 shall not tie into the same vent stack at exactly the same location. These two tank vents shall be tied into the same stack, at least ten feet (10 ft.) apart, for safety reasons.

   See details for separate ventilation fan and / or ducting for this room, which is not part of this neutralization system, shown on HVAC drawings by HVAC Contractor.

   See details for eye wash and emergency shower, which is also not part of this neutralization system, shown on Plumbing Drawings.

S. Warranty and Insurance: Entire system shall include a one-year warranty on all components, except pH electrode. Manufacturer shall provide insurance certificate for equipment and system being provided, herein. Manufacturer shall show that this type of system is part of their standard products.

T. Drain line Hookups: A regular sanitary drain line house trap or in-line trap shall be installed after this system, to prevent sanitary or sewer gases from coming back into this neutralizing system.

2.50 AUTOMATIC ELEVATOR SUMP PUMP & BASIN (SP1)

A. Furnish and install one (1) Zoeller model #BN153 Automatic Sump Pump, or equal by Pentair or Liberty Pumps, in each elevator sump basin which is piped to the elevator sump pit with the following features:
   1. Durable, cast iron construction.
   2. Corrosion-resistant, powder coated epoxy finish.
   3. Stainless steel lifting handle.
   4. Assembled with stainless steel bolts.
   5. Non-clogging, engineered thermoplastic, vortex impeller design.
   6. Model 153: ½ HP, passes ¾" spherical solids.
   7. Motor: 3450 RPM, oil-filled, hermetically sealed, automatic reset thermal overload protected.
   8. Carbon/Ceramic seals.
   9. Upper sleeve bearing and lower ball bearing running in bath of oil.
   10. 20' UL listed power cord with molded 3-wire plug.
   11. 1-1/2"NPT vertical discharge.
   12. BN standard model includes a 20' variable level float switch constructed of PVC/polypropyelene encased, omnidirectional, includes mounting clamp,
   13. Operates at temperatures to 130F in effluent applications.
   14. ½ HP, 115V - 1Ø power, 10.5 Amps.

B. Furnish and install one (1) 24" diameter x 84" tall fiberglass sump pump basin for each elevator sump pump. See installation instructions for recommendations.

   1. Where required, provide H-20 load rated hatch/access cover. H-20 load rated hatch/access cover is designed for 16,000 LBS load rating with a 30% impact factor applied over a 10"x20" area. They are intended for use in off-street locations with occasional traffic.
   2. At both elevator sump pump basin location, the piping is not intended to penetrate through the cover. All piping connections are below grade and offset to suitable riser locations. Coordinate power for the sump pump and below grade conduit/tank mounted electrical outlet with the electrical contractor.

C. Furnish and install high water level alarm for the sump basin similar to Zoeller Pump Company APak Indoor Alarm or approved equal. The alarm unit monitors liquid levels in sump pump basins. In addition, the Z Control® Enabled version of the APak can connect to the Z Control® Cloud with its built-in Wi-Fi®. It features green Power On LED, red Input 1 and Input 2 LED's, an audible buzzer normally closed dry contacts, and a Silence/Reset/Test button. The APak® plugs into a 120V, 60 Hz receptacle. Battery backup power is applied by two (2) standard alkaline AA batteries, which are not included and must be purchased separately.

   1. Provide similar alarm for the pH Neutralizing Pit and the two pH Neutralization tanks.

2.51 WATER FILTER FOR BOILER RECIRCULATION LINE

A. The boiler manufacturer recommends a whole house filter with a 10-micron cartridge installed in the recirculation piping. These shall be similar to Parker model #EHG01D1T, Aqua-Pure model #SST2HB, or equal.

2.52 TEMPORARY FACILITIES AND CONTROLS

A. General: Filed Subcontractors shall obtain required permits for, and provide scaffolds, staging, and other similar raised platforms, required to access their Work as specified in Section 01 50 00 - TEMPORARY FACILITIES AND CONTROLS and herein.

1. Scaffolding and staging required for use by this Filed Subcontractor pursuant to requirements of Section 01 50 00 - TEMPORARY FACILITIES AND CONTROLS shall be furnished, erected, maintained in a safe condition, and dismantled when no longer required, by this Filed Sub-Trade requiring such scaffolding.

2. Each Filed Subcontractor is responsible to provide, maintain and remove at dismantling, all tarpaulins and similar protective measures necessary to cover scaffolding for inclement weather conditions other than those required to be provided, maintained and removed by the General Contractor pursuant to MGL (Refer to Section 01 50 00 - TEMPORARY FACILITIES AND CONTROLS and as additionally required for dust control).

3. Furnishing portable ladders and mobile platforms of all required heights, which may be necessary to perform the work of this trade, are the responsibility this Filed Subcontractor.

B. HOISTING MACHINERY AND EQUIPMENT: All hoisting equipment, rigging equipment, crane services and lift machinery required for the work by this Filed Subcontractor shall be furnished, installed, operated and maintained in safe conditions by this Filed Subcontractor, as referenced under Section 01 50 00 - TEMPORARY FACILITIES AND CONTROLS.

PART 3 - EXECUTION

3.1 SPECIAL RESPONSIBILITIES

A. Cooperate and coordinate with other trades in executing work of this Section. Perform work such that progress of entire project including work of other trades shall not be interfered with or delayed. Provide information on items furnished under this Section to be installed by other Sections.

1. Obtain detailed information from manufacturers of equipment as to proper method of installation. Give full information so that openings required for work of this Section might be coordinated with other work and other openings and many be provided for in advance. In case of failure to provide information, cutting and patching will be done at the expense of this Section to the satisfaction of the Architect.

B. During progress of work, remove and properly dispose of resultant dirt and debris and keep premises reasonably clean. Upon completion of work, remove equipment and unused material provided for work.

C. Conduct work so as not to interfere with functioning of existing sewer, water and gas mains. Extreme care shall be observed to prevent debris from entering piping. Confer with Architect as to disruption of water service or their utilities due to testing or connection of new work to existing.

D. All piping and equipment running within trusses must be supported from top chord of truss at panel point. For any alternate configurations or for heavy pieces of equipment coordinate fully with structural engineer for support location before installation.

3.2 MATERIALS AND WORKMANSHIP

A. Work shall be executed in a workmanlike manner and shall present neat appearance when completed. Piping shall run concealed except in mechanical rooms and areas where no hung ceiling exists. Material and equipment shall be installed according to manufacturer's recommended best practice.

B. Materials and equipment shall be new, unless otherwise noted.

3.3 ESCUTCHEONS

A. Escutcheons shall be installed around exposed pipe passing through finished floor, wall or ceiling. Escutcheons shall be heavy cast brass, chrome-plated, adjustable, of sufficient outside diameter to cover sleeve opening and to fit snugly around pipe or insulation.

3.4 SLEEVES AND INSERTS

A. Sleeves for piping between floors and through firewalls or smoke partitions shall be installed with approved packing between sleeves and piping to provide firestop. Coordinate with G.C. requirements.

B. This contractor is responsible for sleeving all pipe penetrations before pouring of slab. Where additional holes are required this contractor shall core drill such holes in coordination with the general contractor and with prior consent of the Architect. Do not cut the composite steel decking before the slab is poured. Provide core drilling after slab is poured and cured. Core openings shall have Link-Seal fire rated penetration closures.

3.5 INTERIOR WATER SUPPLY SYSTEM

A. Water supply piping shall be run as indicated on the Drawings, including new connections to mains and supplies to fixtures. Connections to fixtures shall be from top of mains and piping shall be pitched at least 1 inch in 40 feet in the direction of flow so that it can be drained completely at low points. Provide drain valves where necessary. Piping shall be pitched up towards fixtures for proper air relief.

B. Provide water hammer arrestors of proper size and type at end of each water branch with flush valves as shown on the drawings. All hot water feeds to dishwashers or glasswashers shall have a water hammer arrestor installed.

C. Provide ball type shut-off valves on water branches to individual areas and to each bathroom group and kitchen. Ball valve shut offs shall also be provided at the dishwashers.

3.6 STORM, SANITARY, WASTE AND VENT PIPING

A. Interior horizontal storm, sanitary and waste piping shall be installed in practical alignment at uniform grade of 1/8 inch per foot minimum up to1/4 inch per foot if possible or if required by code such as for waste piping smaller than 4”. Coordinate invert of tie-ins to site piping with site contractor. Piping within building shall be coordinated closely with the work of other trades, in particular the HVAC ductwork.

B. The below grade sanitary waste piping shall be sloped at 1/4 inch per foot. The inverts listed on the drawings reflect this. All other below grade gravity drainage piping shall be sloped at 1/8 inch per foot,

C. In the kitchen, the grease waste and all below grade sanitary waste piping shall be sloped at 1/4 inch per foot. This is indicated on the drawings via the piping inverts, but all inverts shall be verified.

3.7 VENTS THROUGH ROOF

A. All vents extending through the roof which serve the sanitary and waste systems shall extend no less than 18" and no more than 24" above the roof. Where roofs are used for gardens, sun decks or similar purposes, the vent shall extend at least 8 feet above the roof and be increased one pipe size. Offset all vents requiring same in order to avoid interference with HVAC units, to facilitate flashing conditions as well as maintain minimum required distance from all natural and mechanical fresh air inlets. All vents through the roof shall be a minimum of six (6) feet from the roof edge.

B. All gas vents shall run through the roof and shall extend above the roof and shall be provided with ¾" by 1" increaser when required, pipe nipple and Fisher Controls Model No. Y602-17 umbrella type, weather proof bug vent. Off-set vents to avoid interference with roof top equipment, to facilitate flashing as well as maintain minimum required distance from all natural and mechanical fresh air inlets. This contractor is responsible for all gas pipe venting from HVAC equipment and Plumbing Boilers whether or not it is noted or shown on the drawings. This shall include gas pressure regulator vents for any elevated gas pressure piping system.

C. No vent terminal shall be located directly beneath any door, window, or other ventilating opening of the building or of an adjacent building, nor shall any vent terminal be within 10 feet horizontally of such an opening unless it is at least 2 feet above the top of such opening.

D. Vent terminals shall be located at least 25 feet horizontally from all fresh air intake openings. In two instances, the vent terminal is called out to extend at least 2 feet above the top of such opening. Also, vent terminals shall not be installed under PV panels.

3.8 ELECTRICAL ROOMS

A. Piping shall not be installed in or through Electrical Rooms, Electrical Closets, Transformer Rooms, Telephone Rooms or Elevator Machine rooms unless the piping is intended to serve these rooms. No piping shall be installed over electrical panels.

3.9 CLEANOUTS

A. All cleanouts shall be set flush with walls or floors. Finish shall be protected during construction with proper covering. Flush floor cleanouts shall be coordinated so as to not be located beneath any partitions, casework nor beneath any non-potable equipment.

3.10 VALVES

A. All valves shall be furnished and installed under this Section shall be located in a manner to allow proper access for service and repair. This is especially true for shutoff's to restrooms throughout the school where the valves are either located above the ceiling or within the plumbing chases behind access panels.

B. In no case shall valve stem and handle on a gate or globe valve be installed below the center-line of the pipe it serves.

C. Valves shall be tagged as specified for identification on a master Valve Tag Chart.

3.11 FLOOR DRAINS

A. Floor drains shall be furnished and installed by this contractor; he shall be responsible for correctly setting these drains to the proper grade to assure proper drainage from all surrounding areas. Sizes of drains shall be the same size as the pipe it serves. Note that if after the floor is poured and it is determined that the floor drains are the high point, then the floor shall be removed and the drain lowered to allow for drainage.

B. All floor drains indicated to have trap primer connections shall have an integral ½" trap primer connection in the drain body. All trap primers are automatic, not electronic, therefore that should start working as soon as the water is turned on to the building.

C. Trench drain installation:

1. Site preparation: Excavate the area for channel placement wide and deep enough to accommodate the standard channel size and a minimum of 4" concrete encasement on both sides as well as underneath the channel. Channels require a minimum of 4" of concrete support and top of channel must be evenly aligned to the surface of the surrounding slab.

2. Installation: Channel sections are installed from the outlet end of the system, working from either catch basin: or deeper channel sections to shallow channel sections. Insert channels from above to allow ends to interlock. Channel sections shall be placed on brick, rebar basket, Channel Chair low slump concrete, grout slurry, or suspended to obtain correct finished elevation. Cutting will be made, if required, by masonry or concrete saw. Temporary place grate in channel to avoid compression during concrete placement.

3. Concrete Placement: Protect grates and channel interior during pouring concrete. Place concrete in a manner that will not dislodge the channels. Concrete shall be at finished level or 1/8" above the top of the channel to ensure efficient drainage and adequate channel edge protection.

4. Finishing and clean-up: Following final set of concrete, remove grate protection, place grates in final position and engage locking bolts in correct location.

D. Floor drains shall be protected throughout the project with duct tape or any durable cover over the grates. These shall be removed completely at the end of the phase/project so that the drain can be put into service.

E. At the end of the phase/project, all floor drain traps shall be filled with water so create a trap seal. The automatic trap primers, clear-water condensate or equipment drainage will fill the floor drain traps afterwards.

F. Install trap guard inserts were noted on the drawings. Note that some of these are installed in addition to having trap primer connections.

1. Trap guard inserts are also shown to be installed on the piping from the elevator sump to the fiberglass basin and the elevator sump pump. This is to prevent odors from being drawn into the elevator shaft through this pipe. Note that the elevator sump should rarely have any water as it is meant to be a low point if sprinkler flow drains into the elevator shaft. Therefore, the elevator sump pump and piping system will most likely be dry.

2. Trap guard inserts are also indicated in remote mechanical rooms in the building where there is HVAC equipment. Since these are for emergencies only, trap guards should be installed in addition to the automatic trap primer valves shown.

3.12 WALL HYDRANTS, HOSE BIBBS AND ROOF HYDRANTS

A. Hydrants shall be set approximately 24 inches above outside grade and shall include cross connection protection. Loose key stops shall be turned over to the Owner prior to completion. Proposed hydrants are recessed, box mounted which should be normally locked. Note that installation height must be coordinated with architectural elevations.

B. Hose bibbs shall be set approximately 24 inches above finished floor and shall include cross connection protection. Loose key stops shall be turned over to the Owner prior to completion. Proposed hose bibbs are recessed, box mounted in public areas, especially where students have access, and should be normally locked. Other hose bibs are allowed to be exposed in non-public areas like mechanical rooms, the garage, etc.

C. Roof hydrants shall be installed per the Manufacturer’s Instructions. The roof hydrant mounting system ensures that the roof hydrant is securely mounted to the underside of the roof deck to prevent movement when used. There is an 1/8” NPT drain hole at the base of the roof hydrant assembly that must be piped to the nearest drain, as shown on the plans. The roof hydrant outlet shall have a backflow preventer installed per MA Plumbing Code.

3.13 JOINTS AND CONNECTIONS

A. Joints and connections of piping shall be made permanently gas and water tight.

B. Dielectric couplings, waterways or unions shall be used where dissimilar piping materials are joined.

C. Final plumbing and gas connections to all equipment furnished or installed by others shall be by this Section.

D. Cooper-Tubing Grooved Joints: Roll groove end of tube. Assemble coupling with housing, gasket, lubricant, and bolts. Join copper tube and grooved-end fittings according to AWWA C606 for roll-grooved joints. Grooved joint piping systems shall be installed in accordance with the manufacturer's guidelines and recommendations. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified. Gaskets shall be developed and supplied by the system manufacturer. Grooved end shall be clean and free from indentations, projections and roll marks in the area from pipe end to groove. All grooved system components shall be provided by a single manufacturer. A factory trained field representative shall provide on-site training to contractor's field personnel in the installation of grooved piping products. Factory trained representative shall periodically review the product installation. Contractor shall remove and replace any improperly installed products

3.14 INSULATION

A. Insulation shall be applied over clean dry pipe with all joints butted firmly together and sealed with butt strips. Insulation shall run through all hangers and sleeves and have an 18 gauge sheet metal saddle equal to three (3) times the pipe diameter in length, on all pipes over 2 in. in diameter. The open ends of piping insulation is required to be vapor sealed to prevent condensation.

B. All fittings, valves, and exposed supply and waste piping to the handicapped lavatories, etc., shall be insulated as specified. The ends of the insulation shall be tucked snugly into the throat of the fitting and the edge adjacent to the pipe covering tufted and tucked in fully insulating the pipe fitting. The one-piece PVC fitting cover shall then be secured by taping the ends to the adjacent covering.

C. In addition to the regular insulation specified, all exposed piping from floor up to 10 ft. 0 in. shall have a PVC jacket cover applied over the insulation from finish to 10 ft. 0 in. above. All joints shall be sealed with tape.

3.15 CARRIERS

A. All carriers shall be of the hub and spigot type and quality as required under each fixture. Each face plate shall be firmly bolted to floor with 1/2 in. rods.

B. Single closet carriers shall have the rear foot anchored to floor with 1/2 in. rod.

3.16 FIXTURES

A. Fixtures shall be the best product of the manufacturer, shall be without defects in construction or appearance, shall be set true and level, and shall be firmly supported in place without rocking or strain. Fixtures shall be adjusted for proper operation and shall be tested in the presence of the Architect-Engineer. All fixtures shall be thoroughly cleaned and all labels, stickers, and dirt marks shall be removed.

B. The installation of all backing for plumbing fixtures and their accessories not affecting the structure shall be the work of the Plumbing Subcontractor. Cutting and chasing which does not affect the structure shall also be the work of the Plumbing Subcontractor. All cutting and chasing, and installation of all backing for fixtures and accessories, which affects the structure, shall be the work of the Carpenters and/or General Contractor.

C. For the emergency fixtures including eyewash/facewash units and combination showers and eyewash units, the drawings show the drains being piped to sanitary sewer or acid waste piping. They are not shown piped to the floor or indirect to a floor drain as allowed in 248 CMR 10.12(1)(d) which states: “Appliances, devices or apparatus not regularly classed as plumbing fixtures but which have drips or drainage outlets, may be drained by indirect waste pipes discharging into an open receptacle through either an air gap or air break.” If this is the case, the an indirect waste standpipe shall be provided in the wall to capture the drainage from the emergency eyewash/facewash units through an air gap and have a wall access panel installed. Please note that these units will be tested regularly and drainage to the floor is hazardous since the floor drain is not directly under the drain pipe. Note that the floor is sloped to the floor drains in most instances, but this is not enough to prevent water from escaping the containment area. Coordinate with the Worcester Plumbing Inspector to ensure this is an acceptable solution.

3.17 ADJUSTMENT

A. Adjust all flush valves, pressure reducing valves, meter faucets, and water temperature controllers, domestic water boiler, and recirculation pumps for proper outlet temperatures and pressure and flow rate (if applicable).

B. The Plumbing Subcontractor shall be responsible for adjusting and balancing the entire domestic hot water recirculation system. Provide recirculation pump balance report.

3.18 INSTALLATION OF EQUIPMENT

A. Install equipment to avoid interference with structure and work of other Sections, preserve adequate headroom and clear doors and passageways, to satisfaction of Architect, and in accordance with Code requirements. Installation shall permit clearance for access to equipment for repair, servicing and replacement.

B. Manufacturer's Recommendations: Where installation procedures or any part thereof are required to be in accordance with the recommendations of the manufacturer of the equipment being installed, printed copies of these recommendations shall be furnished to the Architect prior to installation.

C. All equipment running within trusses must be supported from top chord of truss at panel point. For any alternate configurations or for heavy pieces of equipment coordinate fully with structural engineer for support location before installation.

D. Provide factory start up on the gas-fired boilers. The electric water heaters do not require factory start-up.

3.19 INSTALLATION OF MEGA PRESS SYSTEMS OR EQUAL

A. Pipe ends shall be cut on a right angle (square) to the pipe. Pipe ends shall be reamed chamfered and all paint, lacquer, grease, oil or dirt shall be removed from the pipe end with an abrasive cloth or Viega pipe end prep tool. Visually examine the fitting sealing element to insure there is no damage, and it is properly seated into the fitting. Insert pipe fully into the fitting. Make a mark with a felt tip pen on the pipe at the face of the fitting. Always examine the pipe to insure it is fully inserted into the fitting prior to pressing the joint. MegaPress fittings hall be joined using Rigid MegaPress Tools. MegaPress fittings shall be installed according to the most current edition of the Viega installation guidelines. Sealing elements shall be verified for the intended use. Installers shall attend a Viega MegaPress installation training class.

3.20 INSTALLATION OF POLYPROPYLENE PIPING SYSTEM

A. Install fittings and joints using socket-fusion, electrofusion, butt-fusion or compression joining as applicable for the fitting or joint type. All fusion-weld joints shall be made in accordance with the specifications and product standards of Nupi Americas. Fusion-weld tooling, welding machines, and electrofusion devices shall be as approved by Nupi Americas. Prior to joining, the pipe and fittings shall be prepared in accordance with ASTM F 2389 and Nupi America’s specifications. Joint preparation, setting and alignment, fusion process, cooling times and working pressure shall be in accordance with Nupi America’s specifications. Installers should be trained and certified by Nupi Americas.

B. Where plenum-rated piping system is needed, the pipe shall be wrapped and/or insulated with standard pipe insulation, field installed. The pipe wrap or insulation shall meet requirements of ASTM E84. The system shall have a Flame Spread Classification of less than 25 and Smoke Development rating of less than 50.

3.21 INSTALLATION OF ELECTRIC WIRING FOR EMERGENCY GAS SHUT-OFF VALVE WITH FUEL GAS SENSORS AND THE ELECTRICAL SHUNT

A. By using dry contact, you can hook up multiple sensors to a single controller. These units can be installed wherever the engineer desires. The only word of caution is that since these are dry contact, the wiring CAN NOT be in the conduit with any voltage carrying wiring at any point, nor can the wiring be loose laid in such a position above the ceiling that it lies across a

fluorescent lamp. Either of these situations MAY result in transient voltages appearing at the panic input and MAY place the unit into a panic state at random.

B. For the Isimet System, if used, the following is required to shunt an electrical panel:
Any LA control panel will have the same configuration. You will need to run 18 gauge 4 conductor wire from CON 5A to an IRE/S, this is a single relay in an enclosure provided by Isimet. There will need jumpers placed on JP7 & JP3. So, the Plumbing Subcontractor needs to provide this additional relay enclosure (IRE/S). The shunt trip breaker must be 120V, and this 120V must be an external power source. The phase leg of the 120V will be wired through the relay contacts with the neutral staying at the shunt breaker.

3.22 INTERIOR GREASE TRAP INSTALLATION

A. Interior grease traps shall be located so as to provide working access to the secured cover.

B. In order to insure maximum efficiency, a flow control fitting shall be provided on the inlet drain to insure that the flow does not exceed the maximum rating of the grease trap.

C. If water is entering the interceptor at excessive temperature (over 150º F), a drain water tempering valve (DTV) and approved backflow prevention assembly must be installed. Most state and local plumbing codes prohibit water above 150º F being discharged into the sanitary sewer. Water above 150º F will weaken or deform PVC Schedule 40 pipe, poly drainage fixtures like interceptors and erode the coating of cast iron (leading to eventual failure).

D. Install interior grease trap unit on solid, level surface in contact with the entire footprint of unit base.

E. The grease trap shall be installed in accordance with the manufacturers written installation instructions.

3.23 INSTALLATION OF TRAP PRIMERS

A. Install trap primers with piping pitched towards drain trap, minimum 1/8 inch per foot (1 percent). Adjust trap primer for proper flow.

B. This valve is designed to be installed on ½” to 1 ½” cold water line, feeding a flush valve or other open and closing valve supply line that is frequently used.

C. Trap Primer valve makeup line to floor drain is recommended to be a minimum of 12” off the finished floor before a 90° elbow can be installed.

D. The furthest recommended distance of makeup line is 20’ to the floor drain.

E. Trap primer make up line must have continuous slope to the floor drain (consult local code requirements).

F. Install with a shut off valve for servicing on the inlet side and a union connection on the outlet side.

G. The valve must be installed level.

H. If using the distribution unit the clear plastic cover must be used.

I. Do not subject the valve to rough in pressure test.

J. An air gap is required to be installed at all trap primer valves to prevent a cross connection between water and sewer.

3.24 DOMESTIC GAS-FIRED BOILER INSTALLATION

A. General: Install domestic gas-fired boilers in accordance with ANSI/Z223.1 and the manufacturers written installation instructions.

B. Support: Install gas-fired boilers on pads oriented so that controls and devices needing service and maintenance have adequate access. Install gas water heaters level.

C. Gas Supply: Provide gas pipe with drip leg, tee, gas cock and union. Provide gas pipe of size shown on drawings or the full size of unit inlet connection. Install piping so as not to interfere with service of unit.

D. Water Piping: Provide hot and cold water piping to units with shutoff valves and unions. Provide recirculating water line to unit with shut-off, check valve, and union connected to cold water piping for the boilers. Recirculation line shall have a whole house water filter installed.

E. Flue: Connect flue and combustion air piping to water heaters with gas tight connections. Use manufacturer approved piping materials for the flue and combustion air piping.

F. The boilers manufacturer representative shall be present with the plumber for start-up. Follow manufacturer’s instructions in the Operations and Maintenance Manual for start-up procedures. Make any and all changes necessary to ensure that the boilers are operating properly.

3.25 INSTALLATION OF GAUGES AND THERMOMETERS

A. Thermometers and pressure gauges shall be installed in such a manner as to cause a minimum restriction to the flow in the pipes and so that they can be easily read from the floor.

B. Thermometers shall be install in the outlet piping from the hot water boilers and tempering valves.

C. Pressure gauges in the cold water system shall be installed at the water meter. They shall also be installed on either side of a pressure reducing valve, either water or gas. There shall be a pressure gage installed on the water main before it leaves the Water Service Entrance Room to indicate the building water pressure.

3.26 PUMP INSTALLATION

A. General: Install plumbing pumps where indicated on the drawings in accordance with manufacturer’s published installation instructions.

B. Access: Provide access space around plumbing pumps for service, but in no case less than that recommended by manufacturer.

C. Support: Install in-line or cartridge pumps supported from piping system.

D. Electrical Wiring: Install electrical devices furnished my manufacturer, but not specified to be factory mounted. Verify that electrical wiring installation is in accordance with manufacturer's submittal and installation requirements of Division 26 sections.

E. Piping Connections: Provide piping, valves, accessories, gauges, supports, and flexible connections as indicated on the drawings.

F. Alignment: Check alignment, and where necessary, realign shafts of motors and pumps within recommended tolerances by manufacturer, and in the presence of manufacturer's service representative.

G. Start-up: Lubricate pumps before start-up. Start-up in accordance with manufacturer's instructions.

H. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.

3.27 STRAINER INSTALLATION

A. General: Place strainers ahead of pressure reducing valves, automatic control valves, pumps, and elsewhere as indicated on the drawings or specified.

B. All strainers shall cleaned prior to occupancy and acceptance.

3.28 ROOF DRAIN WITH OVERFLOW DRAIN INSTALLATION

A. Install roof drains at low points of roof areas, in accordance with the roof membrane manufacturer's installation instructions. All roof drains shall have cast iron domes.

B. Install drain flashing collar or flange so that no leakage occurs between roof drain and adjoining roofing. Maintain integrity of waterproof membranes, where penetrated.

C. Position roof drains so that they are accessible and east to maintain. Note that the plans indicate the location of the primary roof drain and the emergency overflow roof drain (OFD). Ensure that the roof drain orientation matches the plans and that the piping for the primary drains are not piped to the overflow drain outlet.

D. All overflow drain standpipes or water dam shall be 4", no less, to prevent excessive roof water overflow

E. Provide roof drain markers at every roof drain.

F. Downspout outlets shall be set approximately 18 inches above outside grade. Note that installation height must be coordinated with architectural elevations. All downspout outlets shall have a nozzle designed to divert water away from the building to prevent wall stains. These shall be provided with bird screens that can be removed for cleaning. Finish by architect.

3.29 COMBUSTION AIR AND FLUE VENT INSTALLATION

A. The gas-fired boilers shall be vented and supplied with combustion air ventilation air as indicated in the installation and operations manuals for the equipment. The specified materials for the combustion air and flue vents shall be installed. Common venting is not allowed. Label all exposed boiler flue and combustion air piping in the boiler room.

B. Per the drawings, the boiler flue vents have vertical terminations. The flue vent shall terminate a minimum of 30” above the roof surface. The flue vent terminations shall be spaced as directed by the manufacturer. Note that the heating boiler flues are also in close proximity to the domestic hot water boiler flues.

C. Per the drawings, the two (2) domestic water boiler combustion air intakes terminate in an outdoor air plenum behind a louver along with the three (3) heating boiler combustion air intakes. Coordinate with the HVAC Contractor to ensure proper louver sizing and piping coordination.

D. The vent system shall be routed for zero clearance to combustibles as specified by the manufacturer.

E. Vent Installation shall conform to the manufacturer’s installation instructions, its UL/cUL listing and state/local codes. Exposed vent and combustion air piping shall be labelled.

F. The vent system and breechings shall be inspected and cleaned before the final connection to the appliances.

3.30 INSTALLATION OF ELECTRIC HEAT TRACE ON DOMESTIC HW PIPING RUNOUTS AND LAB HW SYSTEM

A. Comply with manufacturer’s recommendations in the Installation and Operation Manual.

B. Apply the heating cable linearly on the pipe after piping has successfully completed any pressure tests. Secure the heating cable to piping with fiberglass tape.

C. Install electric heating cable according to the drawings and the manufacturer’s instructions. The installer shall be responsible for providing a complete functional system, installed in accordance with applicable national and local requirements.

D. Grounding of controller shall be by the Electrical Subcontractor.

E. Connection of all electrical wiring shall be by the Electrical Subcontractor.

F. Pipes must be thermally insulated in accordance with the design guide requirements noted in section 2.10.

3.31 INSTALLATION OF V-LOOP EXPANSION JOINT

A. Inspect joint for shipping damage, insure that the shipping bar is intact.

B. During installation, make sure that the sections of flexible hose and braid are protected from damage and overextension. Weld splatter must be kept away from the flexible legs.

C. Nesting Clearance. Often several V-Loops are nested inside of each other, when this is the case the installer should verify that there is enough clearance between the V-Loops after insulation to allow for the full expected movement. Refer to the submittal for the nest.

D. When required, V-Loops should be insulated with flexible unicellular, mineral wool or fiberglass insulation. Ridged insulations should be avoided on the hose element to avoid point loading the hose. Insulation should be selected and installed to avoid moisture entrapment.

E. For Copper sweat applications, cold strap the fitting that is being soldered or brazed. Thoroughly flush flux from the inside of the system, clean off any flux from the outside of the hose.

F. V-Loops are shipped with shipping bars to maintain the Loops neutral position. Shipping bars must be removed after installation.

G. The 90 return fitting must be supported in a way that allows lateral movement. 2.5” Diameter and smaller loops for +-4” Movement are self-supporting and do not need any additional support.

3.32 INSTALLATION OF PIPE INSULATION

A. GENERAL APPLICATION: The following general conditions apply to the insulation installation.

1. Insulation shall be clean and dry during installation and during application of any finish.

2. Provide removable and replaceable covers on all pumps and equipment requiring insulation that must be opened periodically for inspection, cleaning, or repair.

3. Install insulation, jackets, and coatings continuous through wall and floor openings and sleeves. Provide firestopping as a fire barrier sealing over insulated pipes passing through rated floors and walls.

4. Banding wires shall have the twisted terminals turned down into the insulation, except where vapor barrier would be punctured.

5. Finish open ends of pipe insulation as specified for fittings.

6. All piping and equipment that are scheduled to be insulated shall have a finished jacket, either factory or field applied.

7. Staples shall be installed only on insulation that does not contain a vapor barrier.

8. For all cold piping systems (waste piping receiving condensate discharge and domestic cold water), all components of the piping system shall be insulated and provided with a continuous vapor barrier. Vapor barriers shall be continuous for entire piping system and shall not be pierced except as specified otherwise.

9. Factory applied jacket shall be the finish jacket unless otherwise noted.

10. Maintain vapor barrier where dissimilar insulation products abut.

11. Insulation shall be applied only to pipe that has been previously pressure tested and passed.

B. PIPE SHIELDS: For all piping, insulation shall be continuous on pipe at pipe hangers with protection shields bearing on the outside of the insulation.

C. INSULATION APPLICATION:

1. Type P3 – Glass Fiber Insulation:
   a. Cover pipe with insulation with each section tightly abutted one to another. Jacket shall be lapped and secured with self-adhesive strip.
   b. Abutting ends of insulation shall be covered with 4" wide butt strips smoothly secured with adhesive.
   c. Fittings and valves shall be covered with mitered or molded insulation sections secured with galvanized steel wire and finished with smooth coat of white glass fabric and mastic.

D. FINISH JACKETS:

1. Pre-sized glass cloth jackets shall be secured by a continuous coating of adhesive applied to a uniform thickness. Jacket shall be smooth without wrinkles. Jacket shall be applied to straight lengths of covering only.

2. Flexible glass cloth shall be applied to equipment, valves, fittings, and curved surfaces. Cloth tape shall be smoothly applied and secured with a continuous coat of adhesive. White fabric and mastic to be used on exposed pipe fittings. Tape shall overlap itself and adjacent jackets not less than two inches (2").

3. Apply PVC jacket where indicated with 2” overlap at longitudinal seams and at fitting covers. Seal longitudinal seams by joining with PVC welding solvent. Seal circumferential ends with 1-1/2” PVC tape.

3.33 INSTALLATION OF ELEVATOR SUMP PUMP BASIN

A. Sump pump basins must not be dropped, dragged, or handled with sharp objects and with the exception of the minimal movement involved in a visual inspection, should not be rolled.

B. Sump pump basins should be stored in a secure, controlled area where the potential for accidental damage or vandalism will be minimized. The storage area should be free from sharp objects, rocks or any other foreign solutions of materials that could cause damage to the basins.

C. Excavation for an underground basin should be made with due care to avoid undermining foundations. Maintain a minimum distance of 5 feet plus a slope of 45 degrees from the bottom of the compacted sub-base to the bottom of the adjacent structure, foundations and footings.

D. Backfill: Careful selection, placement and compaction of approved backfill material is critical to a successful basin installation. Backfill material shall be clean, well granulated, free flowing, non-corrosive, and inert and shall be free of ice, snow, debris, rock, or organic material. Approved backfill materials include:

1. Pea gravel, naturally rounded particles, with a minimum diameter of 1/8” and a maximum diameter of 3/4”.
2. Crushed rock, washed and free flowing angular particles between 1/8” and 1/2” size.

Compaction of backfill materials should be adequate to ensure the support of the tank, and to prevent movement or settlement. Backfill materials should be placed in 12” lifts and compacted to a minimum soil modulus of 700 pounds per square foot.

E. When basin installations are located in areas subject to high water tables or flooding, provisions should be made to prevent the basins, either empty or filled, from floating. The buoyancy force to be offset is determined primarily by the volume of the basin. The principle offsetting factors include:

1. Backfill materials.
2. Concrete hold-down pad.
3. Friction between the tank, backfill materials, and the surrounding soil.

All methods of anchoring basins use the weight of the backfill materials to offset the buoyancy forces. The use of supplemental mechanical anchoring methods (a concrete hold-down pad) increases the amount of backfill ballast, which is mechanically attached to the basin. The recommended method of attachment is to pour concrete grout over the basin's anti-flotation flange and concrete hold-down pad.

Requirements of anchorage, thickness of concrete hold-down pads, as well as the size of anchors and reinforcement must be calculated for each installation based on the environmental conditions of that specific installation.

3.34 INSTALLATION OF TRIPLEX BOOSTER PUMP SYSTEM

A. Furnish and install triplex water booster pump system in accordance with manufacturer's recommendations. Refer to the installation and operating instructions manual for the product.

B. Place pump with 3.3 feet clearance in front and on the two sides for inspection and removal.

C. Arrows on the pump base show the direction of flow of water through the pump. Connect the pipes to the manifolds of the pump system. Either end can be used. If flanged, fit a blanking flange with gasket.

D. The pump system must be installed on a plane and rigid concrete foundation which is heavy enough to provide permanent support for the entire system. The foundation must be capable of absorbing and vibration, normal strain or shock. The weight of a concrete foundation must be 1.5 times the weight of the pump system.

E. To prevent the transmission of vibrations to the building, it is recommended to install expansion joints on the piping. Fit expansion joints at a distance of minimum 1 to 1.5 times the nominal flange diameter from the manifold on the inlet as well as the outlet side. This prevents that development of turbulence in the expansion joints. Expansion joints shall have limiting rods to minimize the forces caused by the expansion joints.

F. Prefill the diaphragm tank with nitrogen to the recommended pressure (0.7 x setpoint is the Basis of Design).

G. The booster pump manufacturer representative shall be present with the plumber for start-up. Follow manufacturer's instructions in the Operations and Maintenance Manual for start-up procedures. Make any and all changes necessary to ensure that the booster pumps are operating properly.

3.35 INSTALLATION OF RADON VENT SYSTEM

A. Refer to details on the Plumbing drawings for the portion of the radon system above the roof level. This includes the installation of two radon exhaust fans and a stainless steel mast to an

elevation of 10 feet above the roof level. The HVAC Contractor furnishes the radon fans. Note that the supports for the fans and mast are by this contractor as detailed.

B. The radon piping system, below grade and above grade, is shown on the plumbing drawings and it is the intent for the Plumbing Trade Contractor to install all of this piping.

3.36 ACCESS PANELS

A. Furnish and deliver access panels for access to all concealed parts of the Plumbing System that require accessibility for the proper operation and maintenance of the system. Access panels shall be installed by others. The rating of the access panels shall match the wall assembly rating.

3.37 DISINFECTION

A. Disinfection

1. Each potable water system (cold and hot water) shall be cleaned and disinfected by this Contractor. Cleaning and disinfection shall be performed after all pipes, valves, fixtures and other components of the systems are installed, tested and ready for operation.

2. All hot and cold water piping shall be thoroughly flushed with clean potable water, prior to disinfection, to remove dirt and other contaminants. Screens of faucets shall be removed before flushing and re-installed after completion of disinfection.

3. Disinfection shall be done using sodium hypochlorite in the following manner:

a. A service cock shall be provided and located at the water service entrance. The disinfecting agent shall be injected into and through the system from this cock only.

b. The disinfecting agent shall be injected by a proportioning pump or device through the service cock slowly and continuously at an even rate. During disinfection, flow of disinfecting agent into main water supply is not permitted.

c. All sectional valves shall be opened during disinfection. All outlets shall be fully opened at least twice during injection and the residual checked with orthotolidin solution.

d. When the chlorine residual concentration, calculated on the volume of water the piping will contain indicated not less than 50 ppm (parts per million) at all outlets, than all valves shall be closed and secured.

e. The residual chlorine shall be retained in the piping systems for a period of not less than 24 hours.

f. After the retention, the residual shall be not less than five parts per million. If less, then the process shall be repeated as described above.

g. If satisfactory, then all fixtures shall be flushed with clean potable water until residual chlorine by orthotolidin tests shall be not greater than the incoming water supply (This may be zero).

4. All work and certification of performance shall be performed by approved applicators or qualified personnel with chemical and laboratory experience. Certification of performance shall indicate:

    a. Name and location of the job and date when disinfection was performed.

    b. Material used for disinfection.

    c. Retention period of disinfectant in piping system.

    d. PPM chlorine during retention.

    e. PPM chlorine after flushing.

    f. Statement that disinfection was performed as specified.

    g. Signature and address of company or person performing disinfection.

5. Upon completion of final flushing (after retention period), the plumbing trade contractor shall obtain a minimum of one water sample from each hot and cold water line and submit samples to a State-approved laboratory. Samples shall be taken from faucets located at highest floor and furthest from meter or main water supply. The laboratory shall show the following:

    a. Name and address of approved laboratory testing the samples.

    b. Name and location of job and date the samples were obtained.

    c. The coliform organism count. (An acceptance test shall show the absence of coliform organisms).

6. If analysis does not satisfy the above minimum requirements, the disinfection procedure shall be repeated.

7. Before acceptance of the systems, this Contractor shall submit to the Project Manager, OPM and Architect for his review, three (3) copies of Certification of Performance as specified above.

8. Under no circumstances shall this contractor permit the use of any portion of domestic water systems until properly disinfected, flushed and tested.

B. Cleaning and Adjusting

1. At the completion of the work, all parts of the installation shall be thoroughly cleaned. All equipment, pipe, valves and fittings shall be cleaned of grease, metal cuttings and sludge which may have accumulated by operation of the system for testing.

2. Any stoppage or discoloration or other damage to parts of the building, its finish, or furnishings due to the Plumbing Trade Contractor’s failure to properly clean the piping system shall be repaired by this Contractor at no increase in Contract costs.

3. At the completion of the work, all water systems shall be adjusted for quiet operation.

4. All automatic control devices shall be adjusted for proper operation.

5. All plumbing fixtures and exposed metal work shall be cleaned and polished. Floor drain strainers and traps shall be cleaned of all debris.

6. All items of equipment shall be thoroughly inspected. Any items dented, scratched or otherwise damaged in any manner shall be replaced or repaired and painted to match the original finish. All items so repaired and refinished shall be brought to the attention of the Architect and Clerk of Work for inspection and approval.

3.38 CLEANING

A. Upon completion of work but prior to final system testing, all parts of installation shall be thoroughly cleaned. Fixtures, pipe, valves and fittings shall be completely cleaned of grease, metal cuttings, dirt, etc. Protective covers shall be removed and fixtures shall be cleaned and ready for use.

3.39 TESTING

A. Provide testing of plumbing systems as required by authorities having jurisdiction, including Owner and Architect. Tests shall be conducted as part of work of this Section and shall include labor, equipment, apparatus and services required to perform tests. All tests results shall be documented and signed off on by the Owner, Architect and Engineer.

B. Prior to final acceptance, furnish Architect with certificates of testing and inspection for plumbing systems indicating approval of authorities having jurisdiction and conformance with requirements of Contract Documents.

C. Notify Architect and authorities involved at lest 48 hours prior to testing and inspection. Do not paint, cover or conceal work prior to testing, inspecting and obtaining approval.

D. Provide temporary piping and connections for testing, flushing or draining systems to be tested. Leaks, damage or defects discovered or resulting from test shall be repaired or replaced to like-new condition. Piping must be absolutely tight before it will be accepted and joints shall be made tight without caulking.

E. Tests for Plumbing Systems: Soil, waste, vent, gas, and water piping shall be tested by the Plumbing Subcontractor and approved before acceptance. Underground soil, rain conductor, and waste piping shall be tested prior to backfilling. Equipment required for tests shall be furnished by the Plumbing Subcontractor at no additional cost to the Owner. All tests shall be witnessed and approved by the Plumbing Inspector.

F. Drainage And Venting System Piping: All vent, soil, waste, acid waste, acid vent, and rain conductor shall be tested with water or air before the fixtures are installed.

1. Water Test: Water test shall be applied to the drainage and venting system in their entirety or in sections. If the entire system is tested, all openings in the pipe shall be tightly closed, except the highest opening, and the system shall be filled with water to the point of overflow. If the system is tested in sections, each opening, except the highest opening of the section under test, shall be tightly plugged and each section shall be filled with water and tested with at least a 10 ft. head of water. In testing successive sections, at least the upper 10 ft. of the next preceding section shall be tested so that each joint of pipe in the building, except the uppermost 10 ft. of the system, has been submitted to a test of at least 10 ft. head of water. The water shall be kept in the system, or in the portion under test, for at least two (2) hours before the inspection starts. The system shall be tight at all joints.

2. Air Test: If tests are made with air, a pressure of not less than 5 lbs. per sq. in. shall be applied with a force pump and maintained at least one (1) hour without leakage.

G. Water System: When the roughing-in is complete, and before fixtures are set, the entire hot water recirculation and cold water piping system shall be tested at a hydrostatic pressure of not less than 125 PSI gauge and proved tight at this pressure for not less than four (4) hours in order to permit inspection of all joints. Where a portion of the water piping system is to be concealed before completion, this portion shall be tested separately as specified for the entire system. All water entrance piping up to PRV-station shall be tested at 50 PSI in excess of the street pressure, but not to exceed 200 PSI.

H. Gas System: Gas system shall be tested with air at a pressure of 100 lbs. per sq. in. and maintained at least one (1) hour without leakage.

I. Defective Work: If inspection or test indicates defects, such defective work or material shall be replaced or repaired as necessary and inspection and tests repeated. Repairs to piping shall be made with new materials. No caulking of screwed joints or holes will be acceptable.

J. System Start-Up: The Plumbing Contractor must be present for system start-ups for all plumbing equipment and for the heating boiler start-up since they are gas-fired.

3.40 TESTING, BALANCING AND ADJUSTING

A. Procedures:

1. All domestic hot water generators and hot water circulating systems shall be tested, adjusted, and balanced to the conditions specified and/or shown on the drawings.

2. Performance of systems and components at specified conditions shall be verified by testing.

3. Before request for final inspection, calibrate, adjust, set, test and check all valves, temperatures, and flow rates of systems for operation and performance.

4. The Plumbing Subcontractor shall employ a testing and balancing firm (TAB Agency) to perform the testing and balancing as noted in this section.

5. TAB fieldwork shall not begin on any system/equipment item until signed pre-function checklists (PFCs), pertaining to applicable equipment, have been submitted by the installing contractor to the Cx Team.

6. Copies of all TAB agency generated deficiency reports shall be submitted to the Cx team to ensure that the appropriate installing contractors, and the EOR have received copies of the reports, and to help ensure that immediate attention can be given to addressing and resolving the various deficiencies identified. No retesting of submitted deficiency items shall be attempted by the TAB agency until signed copies of the deficiency reports, certifying completion of the item, have been received back from the applicable installing contractor.

7. A copy of the final TAB report shall be made available to the Cx team at the completion of the TAB fieldwork for the TAB performance verification phase of the Cx procedures. In addition, furnish any data gathered during TAB fieldwork, but not shown in the final TAB paperwork, upon request of same from the Cx Authority.

8. The TAB agency shall provide one (1) technician with full instrumentation for the purpose of verifying the data submitted in the final TAB report. The verification will be conducted by the Cx agency. The Cx authority (CxA) will randomly select a minimum of 25% of the final TAB report data for performance verification purposes and oversee the TAB agency's retesting of these items. If 10% or more of the retested items are found to be plus or minus 10% or more out of tolerance of published final TAB report values, then the TAB agency shall be liable for retesting part or all of the specific system before undergoing further performance verification. However, all out-of-design-tolerance values identified shall be reported and corrected by the construction team.

B. Reports:

1. Report shall indicate pressure, temperature and flow in GPM at the discharge side of each balancing valve referencing the valve tag number.

2. Report shall indicate pressure, temperature and flow in GPM at the suction side of each recirculation pump.

3. Preliminary and final reports shall be prepared and issued to the General Contractor, Architect and Engineer. Copies of final approved balancing report are to be included in the O&M manuals.

C. Products:

1. Provide all instruments, charts, materials, and equipment required to develop a complete test and balance report.

2. The test and balance contractor shall provide testing, adjusting and balancing of the hot water system after the system is fully installed and operational.

D. Execution: Test and balance report shall be a complete document, not limited to, but including at least the following:

1. Domestic Hot Water Balancing Valves: Provide the following as a minimum at the discharge side of each balancing valve referencing the valve tag number.

   a. Pressure.
   b. Temperature.
   c. Flow in GPM.

2. Domestic Hot Water Circulating Pumps: Provide the following as a minimum at each recirculation pump.

   a. Flow rates.
   b. Entering and leaving pressures.
   c. Verify alignment.
   d. Pump speed.

3. Digital and Thermostatic Mixing Valves at Domestic Hot Water Boilers: Setup instructions vary per manufacturer. Setup and balance thermostatic mixing valves per manufacturer recommended instructions found in the mixing valve installation instructions. Provide the following as a minimum.

a. Initial flow and temperature.
b. Intermediate flow and temperature as balancing occurs.
c. Final flow and temperature when system is operational.

3.41 LUBRICATION

A. After complete installation by the Plumbing Subcontractor of any equipment which depends on lubrication for efficient operation, the Plumbing Subcontractor shall properly lubricate per instructions of the manufacturer. This shall be done before any test runs or final operation.

3.42 TRASH AND DEBRIS REMOVAL

A. The General Contractor shall provide dumpsters for use by all subcontractors. During the course of the work, at the end of each workday, subcontractors shall clean up trash and debris caused by their work, and deposit it in the dumpsters, or, at the subcontractor's option, haul it away and dispose of the trash legally. The subcontractor shall do a thorough cleaning of all their debris after scaffold and staging has been removed from an area.

B. Comply with the requirements of Section CONSTRUCTION WASTE MANAGEMENT, for removal and disposal of construction debris and waste.

3.43 PAINTING

A. Plumbing Subcontractor is responsible for painting the exterior gas and gas vent piping (gas service entrance and gas regulator vents) to prevent rusting (rustproof primer and finish coat). All plumbing equipment shall be stenciled with the equipment name. Also, this contractor has the option to stencil the pipe insulation instead of providing self-adhesive pipe labels. Finally, hangers and supports that are exposed (i.e. areas with no ceilings), shall have one coat of non-lead primer.

B. Any painting for gas fittings shall be done after it has been inspected by the local or state Gas Inspector.

3.44 SIGNAGE

A. The Plumbing Subcontractor shall provide signage as required by the Plumbing Specification, the Worcester Plumbing and Building inspectors, and per the MA Plumbing Code. Signage shall be provided at a minimum as follows:

1. For the condensate neutralizer tanks at the domestic hot water boilers regarding frequency of servicing.
2. For the emergency showers and eyewash units regarding flushing of units to minimize water stagnation.
3. At the emergency gas shut-off valve in the boiler room indicating that it should only be used in an emergency.

3.45 SPARE STOCK

A. The Plumbing Trade Contractor shall provide spare parts for some of the plumbing components as listed below:

1. One (1) Flushometer valve for a water closet and a urinal.
2. Six (6) Service Parts for a water closet and urinal Flushometer Valve. Service Parts include a handle, o-ring, vacuum breaker, diaphragm, etc.

3. Six (6) stems for each faucet for lavatories and sinks with at least six (6) installed. Note: If the faucet is used for multiple fixtures, then only six (6) stems for that model faucet are required. Also, provide six (6) aerators for each faucet type.
4. Five (5) water filters for the water coolers with bottle filler keys.
5. Five (5) hose bibb keys.
6. Two (2) wall hydrant handles.
7. Fifty (50) lavatory stops.
8. Backflow preventer repair kits, one per backflow preventer, bagged and affixed to the backflow preventer using zip ties.

B. Coordinate with owner where to deliver and store the spare parts. Provide names of plumbing supply houses where these items and more are available in case plumbing components are needed.

END OF SECTION 22 00 00

Section 23 00 00

HVAC

(Trade Contract Required)

TABLE OF CONTENTS

PART 1 - GENERAL

1.01 GENERAL PROVISIONS - TRADE SUB-BID REQUIRED

A. Work of this Section requires Trade Sub-Bids and is governed by the provisions of the Massachusetts General Laws (MGL), Public Bidding Law Chapter 149A Section 8, Chapter 149 Section 44F, and applicable Section of the MGL, Public Contract Law Chapter 30 as amended. Sub-bids for work under this Section shall be for the complete work and shall be filed in a sealed envelope with the City of Worcester, Department of Public Works and Parks, 50 Officer Manny Familia Way (formerly Skyline Drive), Worcester, MA 01605 at time and place stipulated in the "Invitation to Bid/Notice to Contractors". The following shall appear on the upper left hand of the envelope:

Name of Sub-Bidder: *Print Name of Sub-bidder*

Project: DOHERTY HIGH SCHOOL

Sub-Bid for Section: 23 00 00 - HVAC

B. Each sub-bid submitted for work under this Section shall be on forms furnished by the City of Worcester as required by Section 44F of Chapter 149 of the General Laws, as amended. Sub-Bid forms may be obtained at the Department of Public Works and Parks, Architectural Division, 50 Skyline Drive, Worcester, MA 01605 in person, or by written request.

C. Sub-bids filed with the City of Worcester shall be accompanied by a BID BOND or CASH or CERTIFIED CHECK or a TREASURER'S or CASHIER'S CHECK issued by a responsible bank or trust company payable to the City of Worcester in the amount of five (5) percent of the bid. A sub-bid accompanied by any other form of bid deposit than those specified will be rejected.

D. Additional Requirements:

1. Sub-bidder's attention is directed to Massachusetts G.L. Chapter 149 §44H, as amended, which provides in part as follows:
2. Each sub-bidder shall list in Paragraph E of the "Form for Sub-bids" the name and bid price of each person, firm or corporation performing each class of work or part thereof for which the Section of the Specifications for that sub-subtrade requires such listing, provided that, in the absence of a contrary provision in the Specifications, any sub-bidder may, without listing any bid price, list his own name or part thereof and perform that work with persons on his own payroll, if such sub-bidders, after sub-bid openings, shows to the satisfaction of the Awarding Authority that he does customarily perform such class of work with persons on his own payroll and is qualified to do so. This Section of the Specifications requires that the following classes of work shall be listed in Paragraph E under the conditions indicated herein.
   Sub-Subs required:

Class of Work	Reference Spec.	Paragraphs
Sheet Metal	23 00 00	2.01 & 2.02
Insulation	23 00 00	2.11
Auto. Temperature Control	23 00 00	2.49
Testing, Adjusting & Balancing	23 00 00	3.05

E. The work to be completed by the Trade Contractor for the work of this Section is shown on the following listed Drawings, not just those pertaining particularly to this Trade Contract, unless specifically called out otherwise, regardless of where among the Drawings it appears:

1. The Work of this Trade Contract is shown on the following Drawings:

   H3.1, H3.2, H3.3, H3.4, H3.5, H3.6, H3.7, H3.8, H3.9, H3.10, H3.11, H3.12, H3.13, H3.14, H3.15, H3.16, H3.17, H3.18, H3.19, H3.20, H3.21, H3.22, H4.1, H4.2, H4.3, H4.4, H4.5, H4.6, H4.7, H4.8, H4.9, H4.10, H4.11, H4.12, H4.13, H4.14, H4.15, H4.16, H4.17, H4.18, H5.1, H5.2, H5.3, H5.4, H5.5, H5.6, H6.1, H6.2, H6.3, H6.4, H6.5, H6.6, H7.1, H7.2, H7.3, H7.4, H7.5, H7.6, H7.7

2. Related items which may require coordination or impact work of this trade are shown on the following Drawings:

   EX1.0, EX2.0, EX3.0, EX4.0, C1.0, C1.1, C1.2, C2.0, C2.1, C2.2, C3.0, C3.1, C3.2, C4.0, C4.1, C4.2, C5.0, C5.1, C5.2, C6.0, C6.1, C6.2, C6.3, C7.0, C7.1 C7.2, C8.0, C8.1, C8.2, C9.0, C9.1, C9.2, C9.3, C10.0, C10.1, C10.2, C10.3, C10.4, C10.5, L0.0, L0.1, L0.2, L1.1, L1.2, L1.3, L1.4, L1.5, L2.1, L2.2, L2.3, L2.4, L2.5, L2.6, L3.1, L3.2,

L3.3, L3.4, L3.5, L4.1, L4.2, L4.3, L4.4, L4.5, L4.6, L4.7, IR-1, IR-2, IR-3, S1.01, S1.02, S1.03, S3.01, S3.02, S3.03, S3.04, S3.05, S3.06, S3.07, S3.08, S3.09, S3.10, S3.11, S3.12, S3.13, S3.14, S3.15, S3.16, S3.17, S3.18, S3.19, S3.20, S3.21, S3.22, S4.01, S4.02, S4.03, S4.04, S4.05, S4.06, S4.07, S4.08, S4.09, S4.10, S4.11, S4.12, S4.13, S4.14, S4.15, S4.16, S4.17, S4.18, S4.19, S4.20, S4.21, S4.22, S4.23, S4.24, S4.25, S4.26, S4.27, S4.50, S4.51, S4.52, S4.53, S4.54, S4.55, S5.01, S5.02, S5.03, S5.04, S5.11, S5.12, S5.13, S5.14, S5.15, S5.16, S5.17, S5.18, S5.19, S5.20, S6.01, S7.01, S7.02, AD1.0, A1.0, A1.1, A1.2, A1.3, A1.4, A1.5, A1.6, A1.7, A2.0, A2.1, A2.2, A2.3, A2.4, A2.5, A2.6, A3.1, A3.2, A3.3, A3.4, A3.5, A3.6, A3.7, A3.8, A3.9, A3.10, A3.11, A3.12, A3.13, A3.14, A3.15, A3.16, A3.17, A3.18, A3.19, A3.20, A3.21, A3.22, A4.1, A4.2, A4.3, A4.4, A4.5, A4.6, A4.7, A4.8, A4.9, A4.10, A4.11, A4.12, A4.13, A4.14, A4.15, A4.16, A4.17, A5.0, A5.1, A5.2, A5.3, A5.4, A5.5, A5.6, A5.7, A5.8, A5.10, A5.11, A5.12, A5.13, A5.14, A5.15, A6.1, A6.2, A6.3, A6.4, A6.5, A6.6, A6.7, A6.8, A6.9, A6.10, A6.11, A6.12, A6.13, A6.14, A6.15, A6.16, A6.17, A6.18, A6.20, A6.21, A6.22, A6.23, A6.24, A6.25, A6.26, A6.27, A6.28, A6.29, A6.30, A6.32, A6.33, A7.0, A7.1, A7.2, A7.3, A7.4, A7.5, A7.6, A7.7, A7.8, A7.9, A7.10, A7.11, A7.12, A7.13, A8.1, A8.2, A8.3, A8.4, A8.5, A8.6, A8.7, A8.8, A8.9, A8.10, A8.11, A8.12, A8.13, A8.14, A8.15, A8.16, A8.17, A8.18, A8.18a, A8.19, A8.20, A8.21, A8.22, A8.22a, A8.23, A8.23a, A8.24, A8.24a, A8.25, A8.26, A8.27, A8.28, A8.30, A8.31, A8.32, A8.33, A8.34, A8.35, A8.36, A8.37, A8.38, A8.39, A8.41, A8.42, A8.43, A8.44, A8.45, A8.46, A9.0, A9.1, A9.2, A9.3, A9.4, A9.5, A10.1, A10.2, A10.3, A10.4, A10.5, A10.6, A11.1, A11.2, A11.3, A11.4, A11.5, A12.1, A12.2, A12.3, A12.4, A12.5, A12.6, A12.7, A12.8, A12.9, A12.10, A12.11, A12.12, A12.13, A12.14, A12.15, K1.1, K1.2, K2.1, K2.2, K2.3, K2.4, K3.1, K3.2, K4.1, K4.2, K4.3, K4.4, K5.1, K5.2, K6.1, K6.2, K6.3, FP-1.0, FP-1.1, FP-1.2, FP-1.3, FP-1.4, FP-4.1, FP-4.2, FP-4.3, FP-4.4, FP-4.5, FP-4.6, FP-4.7, FP-4.8, FP-4.9, FP-4.10, FP-4.11, FP-4.12, FP-4.13, FP-4.14, FP-4.15, FP-4.16, FP-4.17, FP-4.18, P2.1, P2.2, P2.3, P2.4, P3.1, P3.2, P3.3, P3.4, P3.5, P3.6, P3.7, P3.8, P3.9, P3.10, P3.11, P3.12, P3.13, P3.14, P3.15, P3.16, P3.17, P3.18, P3.19, P3.20, P3.21, P4.1, P4.2, P4.3, P4.4, P4.5, P4.6, P4.7, P4.8, P4.9, P4.10, P4.11, AV1.0, AV1.1, AV1.2, AV3.3, AV3.4, AV3.6, AV3.8, AV3.10, AV3.14, AV3.20, AV4.1, AV6.1, AV6.2, AV6.3, AV7.1, AV7.2, AV7.3, AV8.0, AV8.1, AV8.2, AV8.3, AV8.4, AV8.5, AV8.6, TL3.4, TL3.12, TL3.20, TL4.1, TL4.2, TL6.1, TL6.2, TL9.0, TL9.1, TL9.2, TL9.3, TP1, TR3.4, TR3.12, TR4.1, TR5.10, TR6.1, E0.1, E0.2, E0.3, E0.4, E0.5, E0.6, E0.7, E0.8, E0.9, E0.10A, E0.10B, E0.11, E0.12, E1.1, E1.2, E1.3, E1.4, E1.5, E1.6, E1.7, E1.8, E1.9, E1.10, E1.11, E1.12, E1.13, E1.14, E1.15, E1.16, E1.17, E1.18, E1.19, E2.1, E2.2, E2.3, E2.4, E2.5, E2.6, E2.6A, E2.6B, E2.6C, E2.7, E2.8, E2.9, E2.10, E2.11, E2.12, E2.13, E2.14, E2.15, E2.16, E2.17, E2.18, E3.1, E3.2, E3.3, E3.4, E3.5, E3.6, E3.7, E3.8, E3.9, E3.10, E3.11, E3.12, E3.13, E3.14, E3.15, E3.16, E3.17, E3.18, E3.19, E3.20, E4.0, E4.1, E4.2, E4.3, E4.4, E4.5, E4.6, E4.7, E4.8, E5.0A, E5.0B, E5.0C, E5.0D, E5.0E, E5.0F, E5.0G, E5.0H, E5.01, E6.0A, E6.0B, E6.0C, E6.0D, E6.0E, E9.00, E9.01, E9.02, E9.03, E9.04, E9.05, E9.06, E9.07, E9.08, E9.09, E9.10, E9.11, E9.12, E9.13, E9.14, E9.15, E9.16, E9.17, E9.18, E9.19, E9.20, E9.21, FA1.1, FA1.2, FA1.3, FA1.4, FA1.5, FA1.6, FA1.7, FA1.8, FA1.9, FA1.10, FA1.11, FA1.12, FA1.13, FA1.14, FA1.15, FA1.16, FA1.17, FA2.1A, FA2.1B, FA2.1C, FA2.1D, FA2.1E, FA2.2, FA2.2B, FA2.3, TC1.1, TC1.2, TC1.3, TC1.4, TC1.5, TC1.6, TC1.7, TC1.8, TC1.9, TC1.10, TC1.11, TC1.12, TC1.13, TC1.14, TC1.15, TC1.16, TC1.17, TC1.18, TC2.1, TC2.2, TC2.3, TC2.4, TC2.5, TC2.6, TC3.1A, TC3.1B, TC3.1C, TC3.2A, TC3.2B, TC3.2C, TC3.2D, TC3.3A, TC3.3B, TC3.3C, TC3.4A, TC3.4B, TC3.4C, TC3.5A, TC3.5B, TC3.6, TC3.7A, TC3.7B, TC3.8A, TC3.8B, TC3.8C, TC3.8D, PV001, PV002, PV101, PV102, PV103, PV104, PV201, PV301, PV302, PV303, PV304, PV401, PV501, PV502, PV503, PV504, PV505, PV601, PV602, PV603, PV604, PV605.

3. The complete List of Drawings for the Project is provided in Section 00 01 15 – LIST OF DRAWINGS.

1.02 RELATED DOCUMENTS

A. The Contractor, Subcontractors, and/or suppliers providing goods and services referenced in or related to this Section shall also be bound by the documents identified in Division 00 Procurement and Contracting Requirements and Division 01 General Requirements. All of the Contract Documents, including General and Supplementary Conditions and Division 1 General Requirements, apply to the work of this section. Where paragraphs of this Section conflict, the more stringent requirements shall govern.

B. All work shall comply with all federal, state and local codes and any other authorities having jurisdiction.

C. Sustainable Design Intent: Comply with project requirements intended to achieve the intended certification, measured and documented according to the LEED rating system. Contractor must refer too and comply with Section 018113 - Sustainable Design Requirements.

D. Refer to Section 01 60 00 – Product Requirements: Owner's proprietary products and requirements for the same.

1.03 SUMMARY OF WORK

A. Provide all materials, labor and equipment required to perform the work of this section, as shown on the Contract Drawings and as specified herein, to include the following. When the word "provide" is used in this specification it shall mean to furnish & install. Provide the following:

1. Complete HVAC duct system including diffusers, registers, grilles, dampers, etc.
2. Miscellaneous steel, dunnage, supports, hangers, pads, etc., as shown, and as required.
3. Computer Room AC Units
4. Displacement Chilled Beams, shelving, access sections and accessories.
5. Chilled Beams and accessories.
6. Hot water unit heaters, cabinet heaters & Fin-Tube Radiation.
7. Electric baseboard and cabinet unit heaters.
8. Ductless Split Units
9. Packaged Roof-top HVAC Units
10. Variable Refrigerant Flow System
11. Air Handling Units.
12. Energy Recovery Units.
13. Fan Coil Units.
14. Duct and unit mounted bipolar ionizers.
15. Remote condensing units and associated refrigerant piping.
16. Air Cooled Heat Recovery Water Chiller-Heater
17. Boilers, flue piping and safety interlocks.
18. Heat Exchangers
19. Pumps, piping and all related hydronic accessories.
20. Glycol Feeders
21. Condensate piping and traps.
22. Exhaust Fans and associated ductwork.

23. Insulation, thermal and/or acoustic, for ductwork and piping.
24. Automatic temperature controls.
25. Motor starters and drives.
26. Instruction manuals and startup instructions.
27. Testing and balancing.
28. Water treatment.
29. Equipment bases and supports.
30. All rigging and hoisting of equipment as required.
31. Coring, sleeving and firestopping all holes required of the respective work.
32. Access doors on sheet metal ductwork, sheet metal panels and enclosures.
33. Prefabricated or field erected curbs.
34. Obtain and pay for all permits, fees and approvals required for work under this Section.

B. Related Work Specified Under Other Divisions

1. Contractor must coordinate with other trades for all related work including but not limited to housekeeping pads, electrical interface, roofing, coring, firestopping, painting, electrical, commissioning, etc…

C. Cutting, Patching and Fire-stopping:

1. For cutting and patching, this contractor shall refer to and conform to the requirements of 01 73 29 - Cutting and Patching. All penetrations through the structure shall be sealed air and watertight.

2. Where penetrating a fire rated element must be firestopped by the HVAC subcontractor. All penetrations of the floors and ceiling and other fire rated walls and assemblies shall be firestopped by the HVAC contractor. Fire-stopping of all rated wall, floor, and ceiling penetrations used by this trade-contractor for any work completed under this Section. See Section 07 84 13, Firestopping for required methods and procedures.

3. Walls requiring sound seal, noted w/ STC rating, including but not limited to: Classrooms, offices, media center, cafeteria, gymnasium, and music rooms (for sound control), and thru exterior walls (for water and air seal) to be sealed with non-combustible, water-proof material, as specified in Section 09 29 00 Gypsum Board, both sides of all penetrations.

D. Provide seismic bracing shall be provided regardless of exceptions allowed by code for this seismic category in conformance with the Commonwealth of Massachusetts building code 780 CMR, 9th edition, Chapter 16. Contractor shall hire a seismic consultant to comply with requirements of the code. All equipment and ductwork shall be seismically supported and all piping over 2”. Mechanical seismic control exceptions noted in the code for the buildings seismic category shall not apply. For the purposes of seismic design of the mechanical systems, the building shall be considered an emergency shelter.

E. Reference To Drawings: Work specified is shown on the HVAC drawings and also includes all of the Contract Drawings.

1. The HVAC Trade contractor shall refer to all the Drawings enumerated in the List of Drawings on the title sheet for a full comprehension of the work to be done and for conditions affecting the location and placement of his equipment and materials. These Drawings are intended to be supplementary to the Specifications and any work indicated, mentioned, or implied in either is to be considered as specified by both. Should the character of the work herein contemplated or any matter pertaining thereto be not sufficiently explained in the Specifications or Drawings, the HVAC Trade

contractor may apply to the Architect-Engineer for further information and shall conform to such when given, as it may be consistent with the original intent. The Architect-Engineer reserves the right to make any reasonable changes in location prior to installation at no expense to the Owner. All lines are diagrammatic and exact locations are subject to the approval of the Architect-Engineer.

2. The HVAC Trade contractor shall, at all times, have a foreman or superintendent on the project authorized to make decisions and receive instructions as if the HVAC Trade contractor himself were present. The foreman or superintendent shall not be removed or replaced without the express approval of the Architect-Engineer after construction work begins. The HVAC Trade contractor shall employ only competent and experienced workmen at a regular schedule in harmony with the other tradesmen on the job. The HVAC Trade contractor shall also exercise care and supervision of his employees in regard to proper and expeditious layout of his work.

F. ALTERNATES:

Special attention is called to the fact that it shall be the responsibility of all the General and Trade contractors to thoroughly examine all the alternates and evaluate for themselves as to whether or not these alternates in any way affect their respective sections. In the event that a contractor feels that any alternate(s) do reflect a cost difference, additional or a deduction, in his bid proposal, then he shall stipulate his sum and/or sums under the proper alternate(s) as provided for in the bid proposals. Failure to do so will in no way relieve the herein before stated contractors of their responsibilities regardless of what alternate(s) are selected and no extra cost will be charged to the Owner.

G. This project shall comply with the LEED v4 rating system. The HVAC Contractor must comply with LEED requirements for this project including but not limited to the requirements of the following sections:

1. SECTION 01 81 13 – SUSTAINABLE DESIGN REQUIREMENTS
2. SECTION 01 74 19 – CONSTRUCTION WASTE MANAGEMENT & DISPOSAL
3. SECTION 01 81 19 – INDOOR AIR QUALITY MANAGEMENT
4. SECTION 01 91 00 - COMMISSIONING

It shall be the HVAC contractors responsibility to submit all documentation required of these sections pertaining to division 23 00 00 work. For Section 01 91 00 - Commissioning, division 23 00 00 must provide all personnel as required to fully coordinate with the commissioning agent. The hours of training and instruction outlined in division 23 00 00and the Testing and Balancing requirements shall be in addition to those tests and requirements outlined in Commissioning section and required to the fulfill commissioning obligations.

H. Air Filters:

It is the intent of this specification that all equipment requiring or specified with air filters be furnished with two (2) spare sets of filters (both pre and final) for each piece of equipment in addition to those supplied with the unit and after flush-out. Presuming the unit has not been operated during construction (operation during construction only allowed with written approval from Architect) the set of filters initially installed in the unit shall be utilized during testing and balancing and building flush out. After flush out, a new set of air filters shall be installed leaving the Owner with two (2) full spare sets. All pre-filters shall have a minimum efficiency of MERV 8 and all final filters and single filter units shall have a minimum efficiency of MERV 13.

All RTU, AHU and MAU filter sections must be fitted with differential pressure gauges viewable from the outside of the unit. Gauges shall be connected to EMS where specified elsewhere in this specification.

I. Belts & Spare Stock:
It is the intent of this specification that all equipment requiring or specified with belt drives (i.e. fans, energy recovery wheels in RTU's, AHU's, MAU's exhaust fans, etc…) be furnished with two (2) spare sets of belts for each piece of equipment in addition to those supplied with the unit.

In addition, any items considered consumable or required for routine maintenance and service replacement within the first 18 months of an equipment's operation shall be supplied of adequate quantity to operate the equipment for a period of 24 months.

J. Building Flush Out:

After construction contractor must coordinate and implement building wide flush to meet the requirements of LEED Construction IAQ Management. All equipment with filters shall be fitted with MERV 13 filters during the flush put period. After the flush out period the units shall be provided with new MERV 13 filters (and MERV 8 pre-filters as applicable) installed as specified. Contractor shall assemble a flush out schedule which shall achieve a minimum of 14,000 CF of outside air while holding the spaces between 60°F and 80°F and no higher than 60% RH.

K. Electrical Equipment Requirement:

All HVAC equipment shall have a minimum Short Circuit Current Rating (SCCR) of 20,000 AMP

1.04 LEED v4 GENERAL REQUIREMENTS

A. The work of this Section is required to comply with general requirements and procedures for compliance with prerequisites and certain credits required for the Project to obtain Certified rating based on USGBC's LEED v4 Reference Guide for Building Design and Construction and as outlined in Division 01 Section "Sustainable Design Requirements."

1. The Construction Manager is responsible to coordinate with the work of other Sections and comply with all LEED v4 requirements in accordance with the Contract Documents such that the work carried out by this Section does not compromise the achievement of any other LEED v4 prerequisites and credits applicable to the entire Project.

B. Related Sections for Sustainable Design Requirements:

1. Section 01 25 13 "Product Substitution Procedures" for product substitutions.
2. Section 01 33 00 "Submittal Procedures" for LEED v4 submittal requirements.
3. Section 01 50 00 "Temporary Facilities and Controls" for requirements for temporary facilities.
4. Section 01 60 00 "Product Requirements" for additional LEED v4 submittal requirements.
5. Section 01 74 19 "Construction Waste Management" for waste management, recycling and disposal.
6. Section 01 81 13 "Sustainable Design Requirements" for general procedures for compliance with LEED v4 prerequisites and credits.

7. Section 01 81 19 “Indoor Air Quality Requirements” for material and procedure requirements.

1.05 SUBMITTALS

A. Refer to Section 01 33 00, SUBMITTALS for submittal provisions and procedures. Contractor must also refer too and comply with Section 018113 - Sustainable Design Requirements.

B. Product data: within 30 calendar days after the HVAC Trade Contractor has received the Owner’s Notice to Proceed, submit (7) copies of the following:

1. Coordinated shop drawings, showing proposed layout of equipment, piping, ducts, registers, grilles, controls and other components of the system. All heights, transitions, dimensions, etc… shall be clearly shown.
2. Manufacturers catalog cuts, Samples and other items needed to fully demonstrate the quality of the proposed materials and equipment. In addition to the submittals formerly mention herein submit equipment specification sheets and dimensional data on all equipment including but not limited to the following:
   - Ductwork, registers, grilles, etc..
   - Flue Piping, Combustion air ductwork and accessories
   - Computer Room AC Units
   - Displacement Chilled Beams, shelving, access sections and accessories
   - Chilled Beams and accessories
   - Heat recovery chiller-heater
   - Hot water unit heaters, cabinet heaters, radiant panel heaters & fin-tube radiation.
   - Electric baseboard and cabinet unit heaters.
   - Ductless Split Units
   - Variable Refrigerant Flow System
   - Packaged Roof-top HVAC units
   - Energy Recovery units
   - Air Handling Units
   - Make-Up Air Units
   - Fan Coil Units.
   - Duct and unit mounted bipolar ionizers.
   - Remote condensing units and associated refrigerant piping.
   - Boilers, flue piping and safety interlocks.
   - Heat Exchangers
   - Glycol Feeders
   - Pumps, piping and all related hydronic accessories.
   - Exhaust Fans and associated ductwork.
   - Insulation, thermal and/or acoustic, for ductwork and piping.
   - Automatic temperature controls.
   - Motor starters and drives.
   - Instruction manuals and startup instructions.
   - Testing and balancing.
   - Water treatment.
   - VAV & FVAV Boxes
   - Automatic Temperature Controls

B. Record Drawings

1. Include a copy of the Record Drawings in each copy of the operation and maintenance manual described below. A reproducible set of as-built drawings shall be updated continually through the project and delivered to the Architect at project completion. Record drawings shall also be delivered in both ACAD format and PDF format on a CD.

C. Testing and Balancing Reports

1. Submit four (4) copies of a certified testing and balancing report to the Architect for review and approval. Include all air flow, water flow and temperature readings as outlined herein.

D. Operating Instructions

1. Prior to the completion of all work and the final inspection of the installation by the owner, four (4) copies of a complete Instruction Manual, bound in booklet form and suitably indexed, shall be submitted to the Architect for review and approval. All written material contained in the manual shall be typewritten. In addition, provide a copy of the manual in an index PDF format on a CD.

1.06 INSTRUCTION OF OWNER'S PERSONNEL

A. After completion of all work and all tests and at such time as designated by the owner, provide the necessary skilled personnel to operate the entire installation for a period of forty (40) hours. This 40 hours is in addition to those equipment specific training hours specified elsewhere within this specification. Training shall be broken up into multiple four (4) hour periods at the direction of the Owner. Training must be recorded by the HVAC Trade Contractor and distributed to the Owner on DVD with a copy in each O&M manual. Training shall be videotaped onto indexable CD/DVD and thumb drive in compliance with other parts of the specification. Refer to section 017900 for specific MSBA training requirements.

B. During the operating period, fully instruct the owner's representative in the complete operation, adjustment and maintenance of the entire installation.

C. It shall be division 23 00 00 responsibility to provide all personnel as required to fully coordinate with the commissioning agent. The hours of training and instruction outlined in division 23 00 00 and the Testing and Balancing requirements shall be in addition to those tests and requirements outlined in Commissioning section and required to fulfill commissioning obligations.

1.07 QUALITY ASSURANCE

A. Use adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this Section.

B. The HVAC Trade Contractor's superintendent shall conduct all coordination between the Contractor, the Architect, the Engineers, etc., and shall fully represent the HVAC Trade Contractor's position in his absence. All decisions by the superintendent shall become the responsibility of the Contractor and binding to the Contract. The Contractor shall be responsible for the drawings, and that which is written or implied in the specifications.

C. Without additional cost to the Owner, provide such other labor and materials as are required to complete the work of this Section in accordance with the requirements of governmental agencies having jurisdiction, regardless of whether such materials and associated labor are called for elsewhere in these Contract Documents.

D. Completely coordinate with work of other trades and provide for complete and fully functional installation. Although not specifically shown, provide supplementary or miscellaneous items, devices, appurtenances, and materials incidental to or necessary for sound, secure and complete installation.

E. Before submitting the final proposal examine the site of the proposed work to determine existing conditions that may effect the work, as this section will be help responsible for any assumption in regard thereto.

F. All equipment, ductwork, piping and materials utilized for this project must be protected from exposure to weather until installed. Interior equipment and materials shall not be installed unless the area in which they are being installed is adequately weather tight.

G. Contractor must comply with requirements of Section – Construction Indoor Air Quality (IAQ) Management as well as the SMACNA IAQ Guidelines defined in paragraph 3.02 of this section.

H. Condensate evaporation trays are expressly forbidden on all HVAC equipment.

I. To assure uniformity and compatibility of piping components in grooved end piping systems, all grooved products utilized shall be supplied be a single manufacturer. Grooving tools shall be supplied by the same manufacturer as the grooved components.

1.08 EXAMINATION OF SITE AND DOCUMENTS

A. Bidders are expected to examine and to be thoroughly familiar with all contract documents and with the conditions under which work will be carried out. The Awarding Authority (Owner) will not be responsible for errors, omissions and/or charges for extra work arising from Construction Manager's or Trade Contractor's failure to familiarize themselves with the Contract Documents or existing conditions. By submitting a bid, the Bidder agrees and warrants that he has had the opportunity to examine the site and the Contract Documents, that he is familiar with the conditions and requirements of both and where they require, in any part of the work a given result to be produced, that the Contract Documents are adequate and that he will produce the required results.

1.09 BUILDING FLUSH OUT

A. Upon completion of construction, prior to building occupancy and with all interior finishes and furnishings installed the building shall undergo a flush-out period. to meet the requirements of LEED Construction IAQ Management. All equipment with filters shall be fitted with MERV 13 filters during the flush put period. After the flush out period the units shall have MERV 13 filters installed as specified. During this period the systems shall operate, providing the outdoor quantities scheduled on the drawings for each system and all occupancy or demand ventilation reset schedules which could reduce the outside air levels below those scheduled shall be overridden. For systems with the ability to provide 100% outside air (i.e. economizer), these systems shall be set to operate at 100% outside air with the exception that this operation shall not be allowed if outdoor ambient conditions could damage interior finishes or systems such as if ambient conditions were below freezing. Contractor shall

assemble a flush out schedule which shall achieve a minimum of 14,000 CF of outside air rotation through all spaces while holding the spaces between 60°F and 80°F and no higher than 60% RH.

1.10 WARRANTY

A. The HVAC Trade Contractor shall guarantee every component part of each system for a minimum of one-year parts and labor from date of substantial completion. The HVAC Trade Contractor shall also provide the Owner with factory warranties for all equipment. For equipment with compressors such as the condensing units, packaged rooftop and ERU units, heat pumps, etc… provide extended five-year (or longer per manufacturer such as on VRF condensers) warranty on compressors. Refer to extended warranty below and respective specification sections herein for additional warranty requirements.

B. For the following pieces of equipment provide extended 3-year full warranty starting from the date of substantial completion:
- RTU's
- AHU's
- MAU's
- Boilers
- Condensing Units
- VRF related condensers, branch selectors, fan coils and controls.
- Heat recovery chiller-heater.

Warranty shall cover all parts and labor including both factory and field installed control components.

1.11 SEQUENCING

A. Phasing: Refer to Section 01 10 00 - SUMMARY, and Drawings for phasing and milestone completion requirements which affect the Construction Manager's Work and the Work of this Trade Contractor.

B. Coordinate work of this Trade Contract with that of other trades, affecting or affected by this work, and cooperate with the other trades as is necessary to assure the steady progress of work.

C. Do not order or deliver any materials until all submittals, required in the listed Specification Sections included as part of this Trade Contract, have been received and approved by the Architect.

D. Before proceeding with installation work, inspect all project conditions and all work of other trades to assure that all such conditions and work are suitable to satisfactorily receive the work of this Section and notify the Architect in writing of any which are not. Do not proceed further until corrective work has been completed or waived.

E. Refer to the Construction Managers Supplemental Instructions to bidders, section 00 73 00, Project Phasing Requirements Section 01 12 00, for summary of partial work that has been completed, and this contractors coordination and work responsibilities for the remaining scope, briefly summarized as follows:

a. Coordination drawings have progressed setting some ductwork and riser/chase locations.

PART 2 - PRODUCTS

2.01 DUCTWORK

A. All duct runs shall be checked for clearances before installation of any ductwork. Above hung ceilings, duct locations, and elevations must be coordinated with work of other trades to avoid conflicts with structure, piping, conduit, light fixtures, and cable trays.

B. All sheet metal ducts shall be constructed of galvanized iron sheet G-60 galvanized steel meeting ASTM A924 and A653 of bend forming quality. The following specialty ducts shall be used:
1. Ducts forming exterior louvers plenums as well as exhaust ducts from clothes dryers shall be fabricated from aluminum.
2. Ducts for the dishwasher exhaust shall be 20 gauge #316 stainless steel with watertight seams. If welded than 18 gauge shall be used.
3. Ducts for the kitchen hood exhaust systems shall be 18 gauge #316 stainless steel all welded construction.
4. Ducts for fume hood exhaust systems shall be 18 gauge #316 stainless steel.
5. Ducts for elevator shaft ventilation and smoke control systems where applicable shall be 18 gauge.
6. Smoke control ductwork (i.e. stair pressurization) shall be rated for 3” w.c. and be pressure tested to 1.5 times its required rating of 3” to 4.5”.
7. Exhaust ducts serving wet areas such as shower rooms and locker rooms shall be fabricated out of aluminum.
8. Ducts serving dust collector exhaust system shall be spiral round galvanized steel, minimum 18 gauge and shall include a complete grounding wire system from collector to each terminal inlet.
9. At all clothes dryer exhaust wall outlets provide an aluminum hooded wall cap with integral backdraft damper similar to model #SFB-4P as manufactured by Seiho or approved equal.

C. Duct construction shall be in accordance with best practices and latest SMACNA requirements for metal gauges, joints, reinforcing, and supports. Ductwork within 20 feet of an air handler (AHU), rooftop unit (RTU) or energy recovery unit (ERU) supply and return or exhaust fan shall be minimum 16 gauge or 2 gauges heavier than SMACNA standard, whichever is greater (heavier gauge), to reduce breakout noise. All ductwork shall be rated for a minimum pressure classification of 3”w.g. where located upstream of VAV terminals or used for the smoke control system, kitchen hood exhaust or elevator shaft exhaust. Smoke control ductwork (i.e. stair pressurization) shall be pressure tested to 1.5 times its required rating (i.e. 4.5”). Ductwork connecting to the dust collector ductwork shall be rated for 10”w.g.. Elsewhere the ductwork shall be rated for 2” w.g. or higher rating as recommended by SMACNA standards. All exposed ductwork shall be constructed and hung to provide a neat, smooth, finished appearance. Cadmium plated sheet metal screws shall be used on all exposed ductwork. Ducts shall be free from expansion or contraction noises or rattling when fans are turned on or off.

D. Round ductwork shall be spiral formed galvanized steel of standard gauge as manufactured by United Sheet Metal, Spiramatic, Semco, or equal. Refer to Articles on Spiral Round and Double Wall Spiral Round for additional information.

E. Duct sizes change in shape or dimensions and offset as required to clear structural members and to coordinate with other trades. All changes must maintain the same friction loss as the original duct (i.e. similar free area) and must meet the latest ASHRAE and SMACNA standards.

F. The centerline radius of all duct elbows where shown on Drawings shall be at least one and one-half the width of the duct. Where building conditions do not allow for this radius, provide double wall airfoil turning vanes or, if in a sound attenuated duct, provide acoustical attenuating turns.

G. Duct sections 1 ft. 6 in. wide or less shall be butted together and jointed with flat drive cleats 2-1/8 in. wide. Top and bottom cleats shall be cut flush with duct and side cleats bent over to make a tight joint. Standing bar slips as specified for ducts over 18 in. may be used at the HVAC Trade contractor's option.

H. Ducts from 18 in. to 30 in. wide shall be jointed with 1/8 in. standing bar slips made of metal the same as or heavier than duct sheets. Joints in ducts with either dimension over 30 in. shall have 1 in. standing bar slips on those sides over 30 in. Where sides are over 42 in., the standing bar slips will be reinforced with 1-1/2 in. by 1-1/2 in. by 1/8 in. angles. Additional angle stiffeners not over 60 in. apart shall be provided between joints. Ducts over 60 in. in width shall be jointed with 1-1/2 in. by 1/8 in. angle irons riveted to ductwork on all sides with 1/8 in. rivets at not more than 4-1/2 in. on centers, sections bolted with 3/16 in. stove bolts at not over 6 in. centers, sheets turned over angles into joint at least 1/4 in.

I. Sheet metal screws 3/4 in. No. 10 may be used to attach stiffener angles to ductwork to secure seams, spaced not over 12 in. on centers and not less than two (2) per side of 12 in. or more, except where specified otherwise. Button punching shall not be used, except for pre-erection attachment of fittings.

J. Provide hinged galvanized steel access and inspection doors opposite each motorized & gravity damper, at each fire damper, and at every duct mounted control device. In addition, provide access doors of sufficient quantity and location to allow for complete internal access of all ductwork systems for future cleaning and inspection but in no case less than every 20 feet and at every change in direction. Doors shall be of rigid construction with cast type rotary latches. Where space limitations do not allow full swing of the access door, two (2) rotary type latches shall be used. Doors located in insulated ducts shall be furnished with extended frames to serve as a stop for insulation. Insulate doors located in insulated ductwork. All doors shall be gasketed. Door shall be 10 in. by 12 in. minimum except where limited by duct width and shall be larger where necessary for access to fire damper fusible links or other devices. Access on exposed ductwork shall be located so as to conceal them from obvious view from building occupants (i.e. top side of ductwork).

K. Hangers for all rectangular ducts 4 sq. ft. in area or above shall be round bar type fastened to 1-1/4 in. by 1-1/4 in. by 1/8 in. angles under the ducts.
   1. Ducts less than 4 sq. ft. in area shall be hung with black 1 in. by l/8 in. strap iron bent 1 in. under bottom side of the duct and fastened to the duct with sheet metal screws, using not less than two (2) screws per side and as many more so that they are not greater than 6 in. centers.

L. Supports for round and oval ductwork shall be 1 in. by 1/8 in. black strap iron rolled to the perimeter of the duct with ends bent on top of duct and bolted. Hangers at supply diffusers shall be similar but separated at bottom and riveted to ductwork as required for adequate support.

M. Hangers for the round ductwork shall be 1 in. by 1/8 in. black strap iron bolted to supports and lagged into the ceiling construction. Hangers over 24 in. long shall be 3/8 in. rod type with bolted and threaded ends and angle bracket at ceiling.

N. Hangers are to be placed on not greater than 8 ft. 0 in. centers or closer where required so that the ductwork can support the weight of a 200 pound man at any point.

O. Wherever sound insulation lining is called for, the sheet metal duct size shown on the Drawings must be increased to provide the clear inside dimensions or cross sectional area shown on the Drawings. Dimensions shown on the drawings are clear inside.

P. Duct joint sealing, reinforcing, flanges, etc. for square sheet metal ducts shall be based on maintaining airtight ducts at 3 in. w.g upstream of VAV or used for smoke control system and 2 in. w.g. elsewhere maximum static pressure with maximum of 5 percent leakage of total fan capacity, 1/2 of one percent for round and oval ducts. All joints in round and rectangular ductwork shall be sealed with UL classified NFPA approved duct sealer. Off gasing of sealer must comply with LEED requirements for the construction of this building. Seal all ductwork at joists and seams with LEED EQ. Credit compliant water based duct sealer DuctMate® EZ-Seal or approved equal. All ductwork shall be pressure tested as required by code. All smoke control ductwork must be fully pressure tested.

Q. Upon completion of construction and before testing, the interior of all plenums shall be vacuum cleaned. When unit is first turned on, open duct access doors and blow out all foreign matter. Do not run fan without filter.

R. Fire Dampers

1. Construction: UL listed and rated for 1-1/2-hour fire rating in conformance with NFPA 90A and authorities having jurisdiction. All shall be out-of-air stream type dynamic rated fire dampers.
2. Provide fire dampers with access doors where indicated on the plans and in openings in the following locations:
   a. Fire rated wall and fire partition.
   b. Fire rated ceilings and floors.
   c. When required by local and state codes.
3. After installation and prior to building turn over to Owner, test each fire damper, reset and replace fusible links in accordance with NFPA. Submit certified test report.

S. Smoke and Fire/Smoke Dampers:

1. Combination Fire Smoke Dampers meeting the following specifications shall be furnished and installed where shown on plans and/or as described in schedules. Dampers shall meet the requirements of NFPA 80, 90A, 92A, 92B, 101 & 105 and further shall be tested, rated, and labeled in accordance with the latest edition of UL Standards 555 and 555S. Dampers shall have a UL555 fire rating of 1 1/2 hours and be of low leakage design qualified to UL 555S Leakage Class I.

2. Each damper /actuator combination shall have a UL555S elevated temperature rating of 250 F minimum and shall be operational and dynamic rated to operate at maximum design air flow at its installed location. Each damper shall be supplied with an appropriate actuator installed by the damper manufacturer at the time of damper fabrication. Damper actuator shall be electric type for 120 or 24 Volt operation.
3. Damper blades shall be 16 gauge galvanized steel 3V type with three longitudinal grooves for reinforcement. Damper frame shall be galvanized steel formed into a structural hat channel shape with reinforced corners. Bearings shall be sintered bronze sleeve type rotating in extruded holes in the damper frame. Blade edge seals shall be silicone rubber designed to inflate and provide a tighter seal against leakage as pressure on either side of the damper increases. Jamb seals shall be stainless steel compression type. Blades shall be completely symmetrical relative to their axle pivot point, presenting identical resistance to airflow in either direction or pressure on either side of the damper.
4. The Damper Manufacturer's submittal data shall certify all air performance pressure drop data is licensed in accordance with the AMCA Certified Ratings Program for Test Figures 5.2, 5.3, and 5.5. Damper air performance data shall be developed in accordance with the latest edition of AMCA Standard 500-D. Dampers shall be labeled with the AMCA Air Performance Seal.
5. Damper must be rated for mounting vertically (with blades running horizontal) or horizontally and be UL 555S rated for leakage and airflow in either direction through the damper. Each damper shall be supplied with a 165 F RRL. The RRL/OCI has built in open closed indicators and switches.
6. The basis of design is Greenheck Model FSD-211, Ruskin or approved equal.
7. After installation and prior to building turn over to Owner, test each smoke damper and fire/smoke dampers, reset and replace fusible links as applicable in accordance with NFPA. Submit certified test report.

T. Backdraft Dampers: Other than for small (less than 10” round and 300 CFM applications) backdraft dampers shall be of the adjustable counterweighted type similar to Ruskin CBD2 series or equal Greenheck BR series. Dampers shall be constructed of extruded aluminum and have vinyl edge seals. Dampers shall have adjustable counterweights which may be adjusted to relieve pressure at differentials less than 0.01”. Damper leakage shall not exceed 15 CFM per SF. Provide access doors on ductwork and enclosures at each damper to access damper and weights.

U. At branch ducts, provide manually operated dampers of the type and arrangement shown on the Drawings, two gages heavier that the duct in which installed and equipped with locking quadrants. **All branch take-offs shall be made with 45° or full Bellmouth type fittings. Spin-in, stick-on and straight taps take-offs shall not be allowed**.

V. Volume dampers, provide single and multi blade manually adjustable dampers as shown on drawings in all duct splits and branch connection of supply and exhaust air systems.

W. For all areas where dampers will be made inaccessible either due to height or hard ceiling without access panels, remote balancing dampers shall be of either the low voltage electric design or cable design shall be used. This shall apply to all volume dampers in the Auditorium space and elsewhere where needed. Provide Greenheck model #RBD-10 series (rectangular), #RBDR50 (round) or #RBD-15 (rectangular over 1” w.g.) or approved equal for all volume dampers in the auditorium space and elsewhere where shown on the drawings or required for access. Dampers shall have a minimum UL555 differential pressure rating of 1” (4” for #RBD-15) and a minimum velocity rating of 2,000 fpm. Dampers shall be constructed of 20-gauge galvanized steel and have a 9-volt actuator.

Provide stainless steel multi-port connectors, single gang outlet box, plenum rated cable and cable couplers. Provide EZ Balance Remote controller with open close toggle buttons and damper position and battery status lights and deliver to Owner at completion of project balancing.

X. Flexible duct shall be 2.0" thick insulated low-pressure type with foil vapor barrier as manufactured by Automation Industries, Thermaflex type MKE ATCO Greenguard or equal. Minimum installed R-value shall be 6.0 within the heated building envelope and 12.0 outside the buildings heated envelope. Maximum length of flex duct is 5 feet. Secure with tie straps and seal with duct tape. Flexible duct upstream of a VAV terminal shall be metal type Class 0 similar. Secure with metal band fasteners and seal joints with duct sealer. Flexible duct shall not be allowed in areas where the duct is not concealed by a ceiling. Bends and turns in flexible ductwork must not exceed a 90 degree angle.

For flexible ductwork exposed within a finished space such as the auditorium and other spaces, provide flexible ductwork with black PSK-faced insulation. Product such as Johns Manville Microlite Black PSK or approved equal may be filed applied with insulation value and characteristics as noted above. Fiberglass reinforced tape shall also be black in these applications.

Y. Acoustic insulation: All supply, return, and exhaust air ducts as well as return air plenums and shafts shall be lined internally with 1.5" inch thick acoustical liner equal to Owens Corning QuietR® Type R-6 or Knauf Insulation Rigid Plenum Liner Board manufactured with ECOSE® Technology or equal, k=0.25 at 75 degree F. mean temperature for rectangular ductwork and Owens Corning QuietZone® 1.5"thick spiral duct liner, k+0.25 at 75 degree F. mean temperature for spiral and round ductwork. Minimum installed R Value shall be 6.0. Liner shall extend for a minimum of 20 feet (or more if indicated on drawings) from all air moving equipment (ERU's, AHU's RTU's & EF and Fans). Apply minimum 8 feet downstream of all VAV, FVAV, FC & FCU regardless of what drawings reflect unless drawings reflect a greater distance. All ductwork serving and within the auditorium area shall be internally lined inclusive of the return air chases. Liner shall clipped and cemented to the inside of the duct or chase/shaft. All seams and edges of liner shall be sealed to prevent fraying in the airstream. Liner shall have an acrylic polymer fiberglass reinforced facing with an antimicrobial coating. Liner shall conform to NFPA and U.L. and ASTM C1071 & ASTM C1104 requirements and have a 25/50 flame/smoke rating. Kitchen hood exhaust, dishwasher exhaust, dust collector exhaust ductwork, garage exhaust as well as exhaust ductwork serving the locker rooms & shower areas are exempt from the internal lining requirement.

Y. SOUND ATTENUATING UNITS

1. Casing gage weight shall be no less as schedule but not less than 20 gage galvanized sheet steel or heavier than 10 gage galvanized sheet metal as reflected on the schedules, with suitable flanges to make clean airtight connections to ductwork. Sound-absorbent material faced with glass fiber cloth and covered with not less than 22 gage or heavier galvanized perforated sheet steel or perforated aluminum. Perforations shall not exceed 4 mm (5/32-inch) diameter, approximately 25 percent free area. Sound absorbent material shall be long glass fiber acoustic blanket meeting requirements of NFPA 90A with microbial coating. Sound absorbent material shall conform to NFPA and U.L. and ASTM C1071 & ASTM C1104 requirements and have a 25/50 flame/smoke rating.

2. Entire unit shall be completely airtight and free of vibration and buckling at internal static pressures up to 2000 Pa (8 inches W.G.) at operating velocities.
3. Pressure drop through each unit: Not to exceed indicated value at design air quantities indicated.
4. Submit complete independent laboratory test data showing pressure drop and acoustical performance.
5. Cap open ends of attenuators at factory with plastic and heavy duty paper, cardboard, or other appropriate material to prevent entrance of dirt, water, or any other foreign matter to inside of attenuator. Caps shall not be removed until attenuator is installed in duct system.

Z. Provide seismic bracing shall be provided regardless of exceptions allowed by code for this seismic category in conformance with the Commonwealth of Massachusetts building code 780 CMR, 9th edition, Chapter 16. Contractor shall hire a seismic consultant to comply with requirements of the code. All equipment and ductwork shall be seismically supported and all piping over 2". Mechanical seismic control exceptions noted in the code for the buildings seismic category shall not apply. For the purposes of seismic design of the mechanical systems, the building shall be considered an emergency shelter.

AA. DOUBLE WALL DUCTS

Where indicated on the drawings, double wall, acoustically insulated ducts shall be supplied. Double wall duct shall be constructed of an outer shell, a 1" thick layer of fiberglass insulation, and an inner metal liner. Insulation shall have a thermal conductivity "K" factor of .26 BTU/hr/sq. ft./ºF or less. The inner metal liner for all spiral and longitudinal seam duct shall be perforated metal. All fittings from fan discharge to a point where 35 lineal feet of spiral duct has been used shall have a perforated metal liner. All other fittings shall have a solid metal liner which may be one even gauge lighter than that shown for perforated liners.

BB. All painting of the exterior of ductwork (all types, spiral, round & rectangular) where noted within the contract drawings such as in the Auditorium, Stage, Gym and elsewhere shall be completed by the painting contractor. However, the HVAC contractor must prepare the galvanized ductwork in these areas prior to erection by properly pre-cleaning and etching the surface with ammonia or alkaline cleaning solution cleaning solution with a PH of between 11 and 12 and sweep blasting the surface with 200 to 500 micron particles. Final in place cleaning, priming and painting of the ductwork shall be by the painting contractor.

CC. All ductwork specified in article 2.01 and 2.02 and all other ductwork shall be shipped to the site with protective film on all open connections to prevent dust from entering. Film shall be reapplied to all open ends as the duct is installed until such time as building is clean and system is ready for start-up. The film requirement shall apply to all HVAC air moving equipment such as AHU's, MAU's, RTU's, VAV's, FVAV's, FCU's, FC's, BC, EF, etc.…

DD. SPECIAL EXHAUST SYSTEMS

a. Hazardous Fume Exhaust Fan shall be licensed to bear the AMCA seal for certified performance in accordance with AMCA Standard 210. The fan shall be in-line style as scheduled and shall have a backward inclined fan wheel with single thickness flat blades welded to both the shroud and back plate. The fan wheel shall be statically and dynamically balanced before assembly. Any required balance weights shall be welded to the outside of the shroud or back plate; no weights are to be installed in the blade air stream. All surfaces of the centrifugal fan shall be painted completely with an acid resistant, polyester powder coating.

The bearings shall be of the pillow block type with cast steel frame and shall be bolted to the structural bearing supports. The fan shaft shall be fabricated of ground and polished cold drawn steel with machined centers and key slots for both the fan wheel and the drive sheave. It shall be given a rust inhibitive asphaltic coating after assembly. The V-belt drive shall be adjustable. The variable pitch sheave shall be factory set at the appropriate position to provide the specified capacity in the approximate midpoint of the adjustment range. All fans shall be provided with a belt guard enclosing both sheaves and V-belts. The belt guard shall have a tachometer hole. All drives shall be rated for no less than 150% of motor load.

The scroll and side sheets of the fan housing shall be fabricated of cold rolled steel of 12-gauge minimum thickness. The scroll and side sheets shall be joined through continuous welding. Spot welded or standing seam construction is not acceptable. The fan housing shall have a minimum of 8 attachment studs with flange locking nuts. Any bolts, self-tapping screws or fasteners that protrude into the housing interior are not acceptable. The fan base shall be fabricated of cold rolled steel of 12-gauge minimum thickness. The bearing supports within the base shall be fabricated of cold rolled steel angles having a minimum 3/16” thickness and they shall be welded to the sides of the base. All seams in the individual components shall be continuous welded. The motor base shall be fabricated of cold rolled steel of 12-gauge minimum thickness. Its position shall be adjustable through the use of bolts that travel in slots in the sides of the fan base. A non-hardening, high elasticity caulking shall be applied during assembly between the mating surfaces of the fan housing and the fan base, of the inlet cone and the fan housing, and the inlet support and the inlet cone.

The assembled fan shall be test run before shipment with “total frequency” vibration measured at each bearing in both the vertical and horizontal planes. Any fan having an average reading of over 3 mils deflection is not acceptable.

Furnish fan platform as required to match specified fan. The platform shall include vibration rail base with suitable vibration isolation for weight load and distribution.

b. AT Articulated Arm Assembly: The two section articulated arm assembly shall be Series AT, comprised of a welded mounting base constructed of structural steel, utilizing a minimum 2” x 2” x 1/8” square tube and 2” x 3” x 3/16” angle iron with integral load bearings of sufficient capacity to handle the torsional stress while providing bind free rotation at the pivot arm connection, one triangular structural support section of 2” x 4” x 1/8” tubular steel and one outboard support strut of 2” x 4” x 1/8” tubular steel joined by a welded steel pivot joint assembly.

   The ducting shall consist of a swivel connection, elbows, and round duct of galvanized construction mounted to the articulating arm sections with two - piece support brackets with adjustable height capability and high temperature flexible hose section with duct attachment collars

c. Hose Suspension System - LFT Spring Retractor: The flexible hose suspension system shall support the flexible hose from overhead when not in use, allowing it to be lowered to the operating level when required. The lifting device shall be a single spring retractor with ratchet stop and ¼” steel suspension frame with cast eyelet and heavy-duty snap ring. The spring retractor shall be capable of lifting at least 25 pounds with 25’ of travel.

d. TSR-S Spring Operated Hose Storage Reel: The hose storage reel frame is to be comprised of formed 12 gauge and 2 x 2 x 1/8 square tubular steel and shall be of

welded construction. The hose drum shall be constructed of 16 gauge steel welded to 12 gauge steel end plates, forming an airtight cylinder. The internal assembly, combined with a low resistance inlet, shall provide efficient airflow through the drum.

The flange-mounted flexible hose assembly shall be bolted to the air inlet of specified diameter; draw band connection is unacceptable. The drum shall be supported at one end by a 1" internally gusseted steel shaft through a heavy cast frame platform bearing, and at the other end by a sealed rotating outlet fitting of a lubristic synthetic material. The hose reel must be of sufficient size to accommodate the specified hose. The outlet fitting diameter, hose length, hose diameter, shall be as shown on the plans and specifications.

The hose storage reel is to be fitted with an enclosed spring mechanism with balanced torque characteristics, factory tuned for hose type and length. Ratchet stops are to be provided so that the flexible hose assembly can be partially or completely extended. The reel is to be equipped with a spring loaded mechanical stop mechanism that limits the number of drum rotations so that it cannot be over extended, and so that it will automatically stop when fully rewound on the drum without stress on the flexible hose assembly.

e. 6” and 7” Hose – HTC Flexible Hose: The hose shall be fabricated of silicone coated glass fabric inner layer and silicone coated nomex outer layer, clinched with an external galvanized steel helix. No adhesives may be used in the construction. The flexible hose is to be capable of withstanding temperatures of 1000°F interior, and be both flame retardant and oil resistant.

2.02 SPIRAL DUCTWORK

A. GENERAL

All round and/or flat oval spiral duct and fittings shall be manufactured by a company whose has been in the business of manufacture of ductwork and spiral duct and fittings for at least ten (10) years. All spiral duct and fittings shall be manufactured by the same firm and shall be as shown on the contract drawings. Acceptable manufactures shall be SEMCO Incorporated or approved equal sheetmetal fabricator. Requirements of Article 2.01 shall also apply to this Article.

All spiral duct and fittings shall be manufactured from G-60 galvanized steel meeting ASTM A924 and A653 requirements. Corrugations between spiral seams on all exposed applications shall not be accepted.

B. CONSTRUCTION

Branch connections shall be made with 90° conical and 45° straight taps as shown on the drawings. All branch connections shall be made as a separate fitting. Factory or field installation of taps into spiral duct shall not be allowed without written approval of the engineer. Manufacturer's published individual fitting performances shall be on file with the design engineer ten (10) days prior to bid.

90º and 45º elbows in diameters 3" round through 10" round shall be stamped or pleated elbows. All other elbows shall be of the gored type, fabricated in accordance with the following:

	Centerline Radius	Elbows less than 30°	Elbows 37° thru 71°	Elbows 72° thru 90°
Up to 1000 fpm	1.0 x diameter	2 gores	2 gores	3 gores
1001 to 1500 fpm	1.0 x diameter	2 gores	3 gores	4 gores
Above 1500 fpm	1.5 x diameter	2 gores	3 gores	5 gores

Where it is necessary to use two-piece mitered elbows, they shall have a minimum number of vanes in accordance with the following:

Duct Diameter	Number of Vanes
3" thru 9"	2
10" thru 20"	3
21" and up	5

Circumferential and longitudinal seams of all fittings shall be a continuous weld or spot welded and sealed with mastic. All welds shall be painted to prevent corrosion.

All field joints for round ducts up to and including 36" diameter and oval ducts up to and including 41” major axis shall be made with a 2" slip-fit or slip coupling. Diameters 38" round and larger shall be provided with AccuFlange, or equal, flanged connections. AccuFlange, or equal, flanged connections may also be used in lieu of slip connections on smaller sizes.

Access doors shall be supplied by the duct manufacturer at all fire and/or smoke dampers.

All flanges and access doors shall be factory installed. Shipments of loose flanges, access doors, or taps for field installation into spiral duct will not be allowed.

C. DOUBLE WALL DUCTS

Where indicated on the drawings, double wall, acoustically insulated round ducts shall be supplied.

Double wall duct shall be constructed of an outer shell, a 1" thick layer of fiberglass insulation (see also acoustic insulation), and an inner metal liner. Liner shall have an acrylic polymer fiberglass reinforced facing with an antimicrobial coating. Insulation shall have a thermal conductivity "K" factor of .26 BTU/hr/sq. ft./ºF or less.

The inner metal liner for all spiral and longitudinal seam duct shall be perforated metal. All fittings from fan discharge to a point where 35 lineal feet of spiral duct has been used shall have a perforated metal liner. All other fittings shall have a solid metal liner which may be one even gauge lighter than that shown for perforated liners.

D. METAL GAUGES

Metal gauges for single wall round ducts shall be as follows:

1. Round Ducts with Maximum 2" W.G. Positive Static Pressure. For 3” w.g. increase all gauges listed 1 gauge heavier. Ducts within 20 feet of air handler and RTU supply, return and exhaust fans shall be minimum 10 gauge to reduce breakout noise.

DUCT DIAMETER	SPIRAL DUCT	FITTINGS AND LONGITUDINAL SEAM DUCT
3" thru 26"	26	24
28" thru 36"	24	22
38" thru 50"	22	20
52" thru 60"	20	18
62" thru 78"	18	16

2. Round Ducts with Maximum -2" W.G. Negative Static Pressure. For 3" w.g. increase all gauges listed 1 gauge heavier.

DUCT DIAMETER	SPIRAL DUCT	FITTINGS AND LONGITUDINAL SEAM DUCT
3" thru 17"	26	24
18" thru 20"	24	22
21" thru 22"	24	20
24" thru 26"	22	20
28" thru 30"	22	18
32" thru 34"	20	18
36" thru 42"	20	16
44" thru 48"	20	18 (Note 1 & 3)
50" thru 60"	18	18 (Note 2 & 3)

Notes:
1. Reinforce with 1" x 1" x $^{1}/_{8}$" girth rings every 6 ft.
2. Reinforce with 1¼" x 1¼" x $^{3}/_{16}$" girth rings every 4 ft.
3. When companion flange joints are used as reinforcement,
   44" to 48" diameter shall be 2" x 2" x $^{3}/_{16}$"
   50" to 60" diameter shall be 2½ x 2½ x $^{3}/_{16}$"

E. Metal gauges for dual wall round ducts shall be as follows unless heavier gages are specified in article 2.01 or elsewhere within this specification:

1. Round Ducts with Maximum 2" W.G. Positive Static Pressure. For 3" w.g. increase all gauges listed 1 gauge heavier.

INSIDE	SPIRAL DUCT		FITTINGS AND LONGITUDINAL SEAM DUCT	
DIAMETER	SHELL	PERF. LINER	SHELL	PERF. LINER
3" thru 8"	26	26 (non-ribbed)	24	24
9" thru 24"	26	26 (ribbed)	24	24
26" thru 34"	24	26 (ribbed)	22	24
36" thru 48"	22	26 (ribbed)	20	22
50" thru 58"	20	26 (ribbed)	18	22
60" thru 62"	18	26 (ribbed)	16	22
62" thru 76"	18	22 (non-ribbed)	16	22

2. Round Ducts with Maximum -2" W.G. Negative Static Pressure. For 3" w.g. increase all gauges listed 1 gauge heavier.

INSIDE DIAMETER	SPIRAL DUCT SHELL	SPIRAL DUCT PERF. LINER	FITTINGS AND LONGITUDINAL SEAM DUCT SHELL	FITTINGS AND LONGITUDINAL SEAM DUCT PERF. LINER
3" thru 8"	26	26 (non-ribbed)	24	24
9" thru 15"	26	26 (ribbed)	24	24
16" thru 20"	24	26 (ribbed)	22	24
22" thru 24"	22	26 (ribbed)	20	24
26" thru 28"	22	26 (ribbed)	18	24
30" thru 32"	20	26 (ribbed)	18	24
34" thru 40"	20	26 (ribbed)	16	22
42" thru 46"	20	22 (non-ribbed)	18 (Notes 1 & 3)	22
48" thru 58"	18	22 (non-ribbed)	18 (Notes 1 & 3)	22

Notes:
4. Reinforce with 1" x 1" x 1/8" girth rings every 6 ft.
5. Reinforce with 1¼" x 1¼" x 3/16" girth rings every 4 ft.
6. When companion flange joints are used as reinforcement,
   44" to 48" diameter shall be 2" x 2" x 3/16"
   50" to 60" diameter shall be 2½ x 2½ x 3/16"

2.03 AIR INLETS/OUTLETS

A. Diffusers, registers and grilles shall be installed where shown on the drawings and shall be of the type, sizes and quantities as indicated on drawings. Manufacturers shall be Titus, Krueger or MetalAire. On return grilles/registers, a sound line plenum box the full duct dimension of the grille/register shall be provided for connection to the branch duct. If entering a return plenum, plenum box shall be lined elbow. For square neck supply diffusers connecting to a round duct, the transition piece shall have a minimum 45 deg. angle.

B. Final color selection of all diffusers registers and grilles shall be by Architect. Submit color chart for review and selection.

C. Displacement Diffusers: Provide displacement diffusers in each area as shown on the drawings and as scheduled.

1. Ceiling units shall be similar to Price model #DF1L-HC as shown on the plans or equal by Metal Aire made for mounting within a suspended ceiling system or other system as shown on the plans. The units shall have an aluminum equalizing baffle behind the displacement face plate and shall also incorporate a 1” custom flow slot diffuser with adjustable pattern controllers for vertical flow defection when providing heated air. The face plate shall be constructed of powdered coated polyester painted heavy gauge steel with no visible fasteners. Frame and plenum shall be fabricated of coated steel. Provide standard white finish on entire exposed face unless a custom color is noted in the schedule or plans. Unit shall be provided with ½” thick foil faced insulation on all exposed above ceiling elements. Unit shall have a 24 volt electric actuator and damper which shall be controlled by the EMS to divert air to the heating segment when in unoccupied heating mode or the cooling segment during all occupied ventilation periods.

2. Wall units shall be similar to Price model #DF1W as shown on the plans or equal by Metal Aire made for mounting concealed within a wall as shown on the plans. The units shall have an aluminum equalizing baffle behind the displacement face plate and have a concealed top ducted inlet collar. The face plate shall be constructed of powdered coated polyester painted heavy gauge steel with no visible fasteners, minimum 18 gauge. Frame and plenum shall be fabricated of coated steel. Provide standard white finish on entire exposed face unless a custom color is noted in the schedule or plans. Unit shall be provided with ½" thick foil faced insulation on all concealed elements. Face shall have stiffeners mounted behind the grid for extra rigidity painted flat black facing the perforation.

3. Refer to Articles on Ceiling Chilled Beams and Displacement Chilled Beams.

D. All diffusers, registers and grilles shall be shipped with protective film on face and connections to prevent dust from entering.

2.04 CEILING CHILLED BEAMS

A. Provide 4-pipe linear active chilled beams as manufactured by NuClimate or Price model #ABCL-HE or Titus or approved equal.

B. Unit shall shall induce room air through the heat exchanger, mixes it with supply air, and delivers the combined air streams into the occupied zone via 2-way slots along the length of the beam. Units shall be configured for a suspended ceiling system of the type indicated on the Architectural drawings.

C. Units shall be of the 4 pipe configuration with both chilled and hot water coils. Other features shall include:

- Adjustable mounting brackets
- Hinged access face to allow easy room side access to the coil and any control component
- White powder coat finish and internally painted black to help hide internal beam elements.
- Perforated heavy duty face.
- Steel plenum
- Extended feature with sloped aluminum condensate drain pan and connection.
- Pressure port for air-side balancing and flow verification
- Copper coils with aluminum fins. Test pressure 450 PSI. Manual drain and vent connections.
- Full condensate pan under coil with drain connection
- ½" NPT connections

D. Each unit shall be provided with 12" long braided stainless steel flexible connectors.

2.05 DISPLACEMENT CHILLED BEAMS

A. MANUFACTURERS

1. Subject to compliance with dimensional, performance, and delivery requirements, provide products by one of the following:
   Displacement Induction Chilled Beams:
   a. Carson Solutions - QLCI “Design by TROX” or equal by Price
   b. Alternate manufacturer must get prior approval from School District and provide documentation of successful execution and operation for no less than five separate projects.
   c. Installing Contractor solely bears all financial risk and responsibility as a result of any and all deviations required to system configuration and operation due to a proposed manufacturer substitution other than the manufacturer listed.

B. CABINET DISPLACEMENT VENTILATION UNITS

1. Basic Unit Construction:
   a. Assembly shall consist of a QLCI air conditioning terminal housed in an architecturally approved enclosure. All internal sheet metal components shall be galvanized to inhibit corrosion. Units shall have perforated panels with internal components painted black to reduce visibility.
   b. Terminal shall consist of 8”ø duct connection(s), a series of injection nozzles, an integral heat transfer coil of 2 pipe circuiting and a perforated equalizing grid behind discharge louver to reduce velocity and noise.
   c. An integral sloped drain pan with fully welded seams shall be piped to remove any condensate that might collect on the coil during cooling operation.
   d. Primary air and water piping connections shall be configured to allow connection of up to three units in series.
   e. No integral fans, compressors or other components requiring a power supply shall be allowed within the terminal room equipment.
   f. Displacement terminals must be able to handle 100% outside air temperatures of 50°F-55°F and provide supply air to the space so that the temperature gradient through the occupied space falls within the guidelines of ASHRAE Standard 55 Thermal Environmental Conditions for Human Occupancy.
   g. Displacement terminal units and system shall have a 3” high toe kick-plate to elevate the painted cabinet above the floor level. For all systems shown with fin-tube radiation mounted behind the displacement system, provide a vented toe kick-plate to allow for air circulation behind the system. Maximum cabinet height to the top of the unit above the floor level shall not exceed 30”.
   h. The heat transfer coil shall be easily removable from unit and fully accessible from the front panel for ease of cleaning.
      1. Coils shall have a continuous aluminum plate fin surface, with seamless copper tubes mechanically expanded into aluminum fin collars for secure, crack-free bonding.
      2. Copper tubes shall be ½” O.D. x 0.028” thick.
      3. Aluminum fins shall have a minimum fin thickness of 0.0055”.
      4. Aluminum fin spacing shall not exceed 8 fins per inch
      5. Coils shall be tested to a minimum of 360 psi and a max of 500 psi. air pressure under water.
      6. Manual air vents shall be located at each circuit high point.
      7. Coils shall be circuited for 2 pipe operation unless schedule or shown otherwise on the plans.

8. Coils shall have integral drain fittings on each circuit low point.
9. Coil connections shall be ½" NPT male threaded fittings
10. Coils shall be delivered cleaned and flushed

i. Drain pans shall be powder coated galvanized or stainless steel. Drain pans must be easily accessible for cleaning via removable front panel.
   1. A ¼" copper drain tube (3/8" OD) is terminated at roughly 1" below the drain pan.
   2. Installing contractor is required to supply and install in the field condensate piping for all drain connections for those units shown as piped with drains.

2. Cabinet Construction
   a. Cabinets shall be constructed of minimum 16-gauge A1008 CS Type B sheet steel and finished with powder coat paint in a custom color as selected by Architect.
   b. Finish shall be DuroCoat Sand Textured Powder Coating to hide small scratches and fingerprints.
   c. Construction shall be sufficient to allow maintenance personnel to stand on the cabinet without any deflection.
   d. Face panels shall be louvered or as otherwise approved by the Architect, pencil proof and at least 45 percent free area. Cabinet structure must have front panel center mullion for rigidity.
   e. Front louvers must be easy to remove and less than 42" for rigidity and mobility.
   f. Front panels should be lockable with multiple cam locks. Sheet metal screws are not an acceptable means for removable panels
   g. Top surface of cabinet shall be flat and allow the entire surface to be used as a bookshelf or other useable storage.
   h. Cabinet shall have structural frame around louver opening to ensure structural strength when louver is removed.
   i. Cabinet shall be rated to support a 250lb load without deflection.

3. Additional Enclosures
   a. Provide accessible utility cabinets and book shelve units as shown on the plans. For rooms with 3 beams, provide book cabinets between beams with passage for ductwork.

   b. Furnish an architecturally approved solid cover with a finish that matches the cabinet for all required units to conceal all vertical ductwork and piping to the units where not enclosed by architectural elements. See plan for locations and field measure height requirements before release of order.

4. Unit Operation
   a. Outside air at the primary airflow rate listed on the plans and schedules shall be conditioned and delivered displacement units at the scheduled supply air conditions.
      i. This conditioned primary air shall be ducted to the lead connection(s) of a series of QLCI terminals.
      ii. Injection of this primary air through nozzles shall induce room air through an integral heat transfer coil and recondition return air prior to its mixing with the primary air.
      iii. The mixture (2/3 induced room air, 1/3 primary air) passes through an equalization plate and is discharged to the classroom at the scheduled outlet velocity to assure displacement ventilation during system operation.
      iv. Using primary (Outside) outside air to drive air out the top is not acceptable for this outside air can't be counted as being introduced into the breathing zone per ASHRAE 62.1-2013.

v. Field provided fin tube radiation that extends the length of the wall and QLCI cabinet and accessories. Outlet louver top panel shall be pencil-proof and integral to the cabinet. Outlet louver top panel shall allow for removable access for cleaning and provided with cam locks. Sheet metal screws and/or compression fittings are not an acceptable means for removable panels.

vi. Cabinet shall have 9/16" raised lip in front of the outlet louvers to limit objects from sliding over the heating outlet. Fin Tube shall have adequate free area to get proper convective airflow during the heating mode. Air shall come from natural convection and not be driven by expensive conditioned primary air or any auxiliary air movement devices. Fin tube shall mount on building wall structure prior to displacement cabinet installation.

5. Classroom Acoustic Performance (Conformance to ANSI S12.60)
   1. Terminals shall be sized and selected such that their collective noise generation shall not contribute to a classroom background sound level exceeding 30dBA per ANSI Standard S12.60. Sound levels of the individual terminals shall not exceed those scheduled (maximum combined NC 30).

6. Accessories and Options (Installing Contractor provided, manuf. may be allowed to furnish pending quality acceptance):
   a. Automatic Flow Limiters (provided by contractor)
      Shall have the capability to measure flow. If other designs cannot measure flow with one unit, a separate low energy loss, flow measuring venturi shall be incorporated on the outlet side of the automatic flow limiter. Manufacturer shall supply automatic flow control valves that must control flow.
      Shall have setter valve functionality to allow for control valve stroke optimization. Automatic flow limiting cartridge(s) will be made of stainless steel. No brass or plastic components allowed.
      Flow rate accuracy will be +/- 5% of design flow rate.
      Shall be of a pressure independent, clog resistant design and shall have an accessible and replaceable cartridge.
      Valve cartridge shall have a single spring range of 2-32 psig, up to ASHRAE recommended maximum GPM. For a typical 2 beam classroom installation a 2 GPM unit would be required similar to Griswold #3K02F series or approved equal. Units with strainers and drain valves shall be acceptable so lonog as accessories meet the intent of the design for these devices.
      The flow rate (GPM) shall be factory preset and not field adjustable unless a cartridge is replaced.
      Cartridges shall be easily removable from valve body without disturbing existing piping.
   b. Wye-Strainers (provided by contractor)
      a. Strainers shall have a 20 mesh rating. Strainers with a lower mesh rating shall not be accepted.
      b. The strainer screen shall be constructed of stainless steel.
      c. The strainer screen shall have at minimum an 8:1 ratio of total area vs. internal pipe diameter.
      d. The strainer body shall incorporate a full-port isolation ball valve for minimum pressure loss. Standard or reduced port ball valves shall not be accepted.
   c. Stainless Steel Braided Hoses (furnished by manufacturer)
      a. One end connection shall swivel to allow for equipment movement during operation.
      b. ½" – 1" shall be made of CPE (Chlorinated Polyethylene).
      c. 1¼" – 2" shall be made of EPDM (Ethylene Propylene Diene Monomer).

d. Maximum working pressures:
e. 500# WPSI Static (½" – 1")
f. 200# WPSI Static (1¼" – 2")
g. Maximum temperature rating: 212°F
h. Hoses shall incorporate stainless steel ferrules.

d. Architectural Cabinet Sections (furnished by manufacturer)
i. All architectural cabinet sections shall be construction of the same gauge metal and paint finish as specified for main unit cabinet, section B.
ii. Bookshelf sections as detailed on plan drawings
iii. Basic Utility Cabinet sections as detailed on plan drawings
iv. Blank Fill Sections for field finish installation (adjusted and installed by contractor)

e. Architectural Countertops (provided by mill work contractor)
Countertops as per Architectural selection shall be installed on top of all cabinet.

C. INSTALLATION: Install units as shown on the drawings and per manufacturers instructions.

D. START-UP: Engage a factory-authorized service representative to provide start-up and training services to Owners staff to adjust, operate, and maintain beam. A minimum of eight hours of such services shall be included in bid

2.06 PIPING MATERIALS – GENERAL

A. Reference is made to specifications of recognized authorities to establish quality. Latest edition of their publications at time of bidding shall be in force.

B. All piping shall have manufacturer's name or trade mark rolled into each and every length of pipe.

C. All threads for screwed joints shall be National Taper Pipe Thread conforming to ANSI B2.1.

D. Grooved mechanical joint pipe, fittings and couplings shall be allowed as an acceptable substitution for welded, threaded or flanged pipe fittings except as otherwise not allowed by applicable codes. Product shall be as manufactured by Victaulic Company of America, Grinnell Mechanical Products, Anvil International Gruvlok or an Engineer approved equal. Fittings shall comply ASTM A536 with grooves or shoulders to accept grooved end couplings. Mechanical couplings shall consist of ductile iron housing, synthetic rubber gasket of a central cavity pressure-responsive design, nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.

1. Rigid type: Housings (12" and smaller) shall be cast with offsetting, angle-pattern bolt pads or tongue and groove design to provide system rigidity and support and hanging in accordance with ASME B31.1 and B31.9..Only designs that require metal-to-metal pad contact permitted. Designs that permit spaces or gaps at bolt pads or require a torque as a primary means of ensuring joint rigidity per written manfuacturer's instructions not permitted. Victaulic Style 107H, Style 07 or W07 or Gruvlok Style 7401, Style 7402, Style 7400.
2. Flexible Type: Use in locations where vibration attenuation and stress relief are required. Victaulic Style 177, 77 and W77 or Anvil International Gruvlok Style 7001.. Three (3) flexible couplings may be used in lieu of each flexible connector at major equipment in accordance with published guidelines.

3. Flange Adapters: Ductile iron housing, flat face, for use with grooved end pipe and fittings, for mating directly with ANSI Class 125, 150, and 300 flanges. Victaulic Style 741, W741 or 743 or Anvil International Gruvlok Style 7012, 7013 or 7788.

E. Any piping conveying well/ground water shall be either schedule 40 PVC or type 'L' copper. Steel piping shall not be allowed. PVC shall only be allowed underground and stubbed into the building wall except as otherwise noted on the plan such as for the spin down filters.

F. Copper Hydronic Pipe Mechanical Fittings by Viega ProPress or approved equal by Elkhart or Nibco: Bronze or copper shall conform to the material requirements of ASME B16.18 or ASME B16.22, and the performance requirements of IAPMO PS117, and ICC LC1002. ProPress fittings ½-inch thru 4-inch for use with ASTM B88 copper tube type K, L, or M and ½-inch up to include 1-1/4-inch annealed copper tube. ProPress fittings shall have an EPDM sealing element and Smart Connect (SC) feature. 2-1/2-inch thru 4-inch shall have a 420 stainless steel grip ring, PBT separator ring, EPDM sealing element and Smart Connect (SC) feature. Sealing elements shall be verified for the intended use

ProPress bronze, or copper fittings: Pipe ends shall be cut on a right angle (square) to the pipe. Pipe ends shall be reamed and chamfered, all grease, oil or dirt shall be removed from the pipe end with a clean rag. Visually examine the fitting sealing element to insure there is no damage, and it is properly seated into the fitting. Insert pipe fully into the fitting. Make a mark with a felt tip pen on the pipe at the face of the fitting. Always examine the tube to insure it is fully inserted into the fitting prior to pressing the joint. ProPress fittings ½-inch thru 4-inch shall be joined using Ridgid ProPress Tools. 2-1/2-inch thru 4-inch ProPress copper fittings shall utilize Ridgid ProPress XLC Rings, and 2-1/2-inch thru 4-inch bronze ProPress fittings shall utilize Ridgid ProPress XL Rings. ProPress fittings shall be installed according to the most current edition of the Viega installation guidelines. Sealing elements shall be verified for the intended use. Installers shall attend a Viega ProPress installation training class.

After ProPress fittings have been installed a "step test" shall be followed. Utilizing air, water, or dry nitrogen, pressurize the system not to exceed 85 psi. Walk the system and check for leaks. If you do not locate any leaks proceed to pressurize the system to the recommended pressures, not to exceed 600 psi. Should you locate a leaking joint that has not been pressed, relieve the pressure from the system, ensure the tube is fully inserted into the fitting and press the fitting. Resume test procedure, after the necessary repairs have been made. This test shall be in addition to the required hydrostatic tests specified elsewhere within the specification.

G. Refer to section on radiant heat and underslab tubing for materials required for those applications.

H. Steel Hydronic Pipe Mechanical Fittings by Viega MegaPress or approved equal via welded, threaded or grooved piping system method: ½-inch through 2-inch shall conform to ASME B31.1, ASME B31.3, or ASME B31.9 MegaPress fittings with zinc and nickel coating for use with IPS carbon steel pipe conforming to ASTM A53, ASTM A106, ASTM A135, or ASTM A795. MegaPress fittings shall have an EPDM sealing element, 420 stainless steel grip ring, separator ring, and an un-pressed fitting leak identification feature. Sealing elements shall be verified for the intended use. Installation must be in accordance to manufacturer's instructions and specifications

Mega Press Systems: Pipe ends shall be cut on a right angle (square) to the pipe. Pipe ends shall be reamed chamfered and all paint, lacquer, grease, oil or dirt shall be removed

from the pipe end with an abrasive cloth or Viega pipe end prep tool. Visually examine the fitting sealing element to insure there is no damage, and it is properly seated into the fitting. Insert pipe fully into the fitting. Make a mark with a felt tip pen on the pipe at the face of the fitting. Always examine the pipe to insure it is fully inserted into the fitting prior to pressing the joint. MegaPress fittings hall be joined using Ridgid MegaPress Tools. MegaPress fittings shall be installed according to the most current edition of the Viega installation guidelines. Sealing elements shall be verified for the intended use. Installers shall attend a Viega MegaPress installation training class.

2.07 STEEL PIPE: HEATING WATER & CHILLED WATER SUPPLY AND RETURN (HWS&R, CHWS&R)

A. Pipe: Black, Schedule 40 conforming to ANSI B125.2 or B125.1. Pipe to be used for welding shall be furnished with beveled ends.

B. Fittings:

1. 2 in. and smaller, screwed, 125 lb. cast iron conforming to ANSI B16.4.

2. 2-1/2 in. and larger, screwed, 150 lb. malleable iron conforming to ANSI B16.3.

3. For welded pipe, all sizes, standard weight black steel welding pattern conforming to ANSI B16.5, B16.9, and B16.25.

C. Joints: Screwed joints shall be made up with Teflon pipe thread tape, Teflon liquid, or other approved non-hardening joint compound applied to male thread only. Welded joints shall be made by oxyacetylene or electric
arc process and comply with latest ASA "Code for Pressure Piping" requirements. Refer to 2.06 for grooved joints and other joining methods.

D. Any pipe 1-1/4 in. and larger may be welded, no pipe larger than 3 in. shall be screwed.

F. Coil connections are to be made so the coil can be removed without cutting pipe.

2.08 HEATING AND CHILLED WATER SUPPLY AND RETURN (CHWS&R and HWS&R), (LESS THAN 3 IN.) AND CONDENSATE DRAIN (C) PIPING (ALL SIZES)

A. Copper Tube Pipe: Type L, hard drawn, conforming to ANSI H23.1.

B. Fittings: Wrought copper solder pattern conforming to ANSI B16.22.

C. Joints: Made with 95-5 tin-antimony solder using non-corrosive flux.

E. The HVAC Trade Contractor has the option to use copper pipe on heating supply and return and heating/cooling water supply and return for 2 in. diameter piping or less.

2.09 REFRIGERANT PIPING & ACCESSORIES

A. All refrigerant piping, liquid, and suction shall be type "ACR" copper tube, hard drawn, shipped to job site with end caps in place. Fittings shall be refrigerant grade copper fittings. Pipe and fittings shall conform to ANSI B31.5 and ANSI B9.1. Piping shall be complete with all refrigerant specialties, of line size, as indicated on the Drawings, and as required by installation requirements. Joints shall be silver soldered or brazed.

B. Piping shall be ASTM B88 type L hard drawn copper tube, cleaned and capped in accordance with ASTM B280, and marked "ACR", with ANSI B16.22 wrought copper or forged brass solder-type fittings.

C. REFRIGERANT PIPING ACCESSORIES
Provide all refrigerant piping specialties with a maximum working pressure of full vacuum to 450 psig and a maximum working temperature of 225 deg F. For systems using R-410A, provide all refrigerant piping specialties with a maximum working pressure of full vacuum to 800 psig and a maximum working temperature of 225 deg F.

Flexible pipe connectors: Double braided bronze hose flexible pipe connectors with brazed end connections.

Filter Dryers: For circuits 15 tons and over provide angle pattern filter dryers with replaceable core. For circuits below 15 tons provide straight pattern filter dryers without replaceable core.

Sight glasses: Two-piece brass construction with brazed end connections. Include color indicator for sensing moisture.

Solenoid Valves: Two way normally closed with two piece brass body, full port, stainless steel plug, stainless steel spring, teflon diaphragm and solder end connections. Provide replaceable coil assembly.

Hot Gas Bypass Valves: Provide with integral solenoid valve, external equalizer connection and adjustable pilot assembly.

Thermostatic Expansion Valves: Brass body, bronze disc, neoprene seat, bronze bonnet, stainless steel spring and solder end connections.

Charging Valves: Provide ¼" SAE brass male flare access ports with finger tight, quick seal caps. Provide 2-inch long copper extension sections.

Check valves: Spring loaded type with bronze body, bronze disc, neoprene seat, bronze bonnet, stainless steel spring and solder end connections.

D. PREPARATION
Remove all foreign material from interior and exterior of pipe and fittings.

E. ERECTION & INSTALLATION
Install all piping parallel to building walls and ceilings and at heights which do not obstruct any portion of a window, doorway, stairway, or passageway. Where interferences develop in the field, offset or reroute piping as required to clear such interferences. In all cases, consult drawings for exact location of pipe spaces, ceiling heights, door and window openings, or other architectural details before installing piping.

Do not route piping through transformer vaults or above transformers, panel boards, or switchboards, including the required service space for this equipment, unless the piping is serving this equipment

Install all valves and piping specialties, including items furnished by others, as specified and/or detailed. Make connections to all equipment installed by others where that equipment requires the piping services indicated in this section.

Refrigeration piping to be installed by firms who are experienced in installation of such piping.

All joints to be brazed and have a melting point greater than 1,125 degrees F. Filler impurities shall not exceed 0.15%. Tubing to be new and delivered to the job site with the original mill end caps in place. Purge all lines with nitrogen during brazing. Provide manual shut-off and check valves as required.

No refrigerant is to be vented directly to the atmosphere except that which may escape through leaks in the system during leak testing. During evacuation procedures, use equipment designed to recover and allow recycling of the refrigerant.

Leak test the system by charging the system with nitrogen to a low 10 psig pressure at first and with the compressor suction and discharge valves closed and with all other system valves open. Increase pressure to 300 psig with dry nitrogen. Rap all joints with a mallet and check for leaks with an electric leak detector having a certified sensitivity of at least one ounce per year. Seal any leaks that may be found and retest.

After completion of the leak test, evacuate the system with a vacuum pump to an absolute pressure not exceeding 1500 microns while the system ambient temperature is above 60°F. Break the vacuum to 2 psig with the refrigerant to be used in the system. Repeat the evacuation process, again breaking the vacuum with refrigerant. Install a drier of the required size in the liquid line, open the compressor suction and discharge valves, and evacuate to an absolute pressure not exceeding 500 microns. Leave the vacuum pump running for not less than two hours without interruption. Raise the system pressure to 2 psig with refrigerant and remove the vacuum pump.

Charge refrigerant directly from original drums through a combination filter-drier. Each drier may be used for a maximum of three cylinders of refrigerant and then must be replaced with a fresh drier. Charge the system by means of a charging fitting in the liquid line. Weigh the refrigerant drum before charging so that an accurate record can be kept of the weight of refrigerant put in the system. If refrigerant is added to the system through the suction side of the compressor, charge in vapor form only.

F. At all penetrations of refrigerant piping through the roof furnish a roof penetration housing similar to the Vault® model AWI series by Roof Penetration Housings or approved equal. Unit shall be constructed of 0.080” thick aluminum housing and 18” high curb, all pre-insualted to R-40 and shall have a UV protected powder coat finish and be selected to support the size and quantity of condensers and pipes being serviced. Each unit shall be furnished with Series 5000 (or series 6000 is pipe size requires) exit seals in sufficient quantity and size to support all the refrigeration piping as well as the required power and control wiring from the exterior unit into the building.

2.10 UNIONS

A. Unions shall be of the same class and material as the pipe and fittings of the system in which they are installed. In black steel piping systems, they shall be 200 lbs. black malleable iron with brass ground joint equal to Dart Figures 0832, 0834, 0835, 0836, or 0838. In copper and brass piping, they shall be 125 lb. bronze or brass with ground joint.

B. Flanged unions for welded pipe shall be weld neck, 150 lb. raised face. Flanged joints shall be packed with impregnated asbestos gaskets placed inside the bolt circle with graphite applied to both faces.

C. Dielectric unions shall be provided between ferrous and non-ferrous piping to prevent galvanic corrosion. The dielectric unions shall meet the requirements for tensile strength of pipe fittings in accordance with Federal Specification WW-U-531 and shall be suitable for temperatures and pressures encountered. The ends shall be threaded, flanged, brazed, or soldered to match adjacent piping. The metal parts of the union shall be separated so that the electrical current is below 1 percent of the galvanic current which would exist with metal-to-metal contact.

2.11 INSULATION

A. General

1. Provide materials complying with NFPA Bulletin 90-A, as determined by UL method 723,NFPA 225-ASTM E 84, and complying with the governing code, with flame spread rating under 25 and smoke developed rating under 50.
2. Insulation properties must meet or exceed the minimum R-values required by the IMC 2015, IECC 2018 and the applicable Stretch Energy Code adopted by the City/Town as applicable and those indicated herein.
3. Where vapor barriers are used, provide intact and continuous throughout.
4. Minimum post-consumer recycled content of 58.5%.
5. Acceptable manufacturers:
   - Owes/Corning Fiberglass
   - Knauf
   - Manville
   - Certainteed

B. Supply, Return & Relief Air Ductwork

1. The following ductwork shall be insulated:
   - All supply air, return air and mixed air ductwork shall be insulated. Supply and mixed air ductwork located within a return air ceiling plenum must be insulated and are not exempt from insulation. Return air ductwork located within a ceiling cavity within the building thermal envelope, where a conditioned area matching the air conditions of the conveying duct is located above and below this ceiling cavity need not be insulated.
   - Relief and exhaust air ductwork from the discharge point to the backdraft or isolation damper (see outdoor air ductwork).
   - All supply air duct and exhaust air ductwork connecting to an energy recovery unit. This includes recovery unit exhaust air ductwork from the unit to the building envelope discharge point.
2. Above ductwork shall be insulated with 2.2-inch-thick flexible blanket duct insulation with vapor barrier, 0.75 lbs. per cu. ft. density glass fiber with maximum K factor of 0.25 at 75 degree F. mean temperature with fire retardant foil/Kraft (FSK) vapor barrier facing. Product shall be Owens Corning SOFTR™ Type 075 or equal with an installed R-value of 6.0 or greater. All seams and joints shall be taped with matching fiberglass reinforced foil vapor barrier tape. Exposed supply and return ductwork located within the conditioned it serves need not be insulated. Duct indicated as being internally lined

need not be externally insulated except when located on the roof or within an unconditioned space.

For ductwork exposed within a finished space such as the auditorium and other spaces, provide black PSK-faced insulation similar to Johns Manville Microlite Black PSK or approved equal with insulation value and characteristics as noted above. Fiberglass reinforced tape shall also be black in these applications.

3. Ductwork located outside the building thermal envelope but not exposed to the exterior weather (see Exterior Ductwork paragraph) shall be insulated as noted above but with 4"+ thick insulation having and installed R-value of 12.

C. Outdoor Air Ductwork

1. All outdoor air ductwork including combustion air ductwork and outdoor and relief/exhaust air louver plenums shall be insulated with 4.4 inch thick flexible blanket duct insulation with vapor barrier, 0.75 lbs. per ft. density glass fiber with maximum K factor of 0.24 at 75 degree F mean temperature with fire retardant foil/Kraft (FSK) vapor barrier facing with a minimum installed R value of 12. Ductwork within mechanical rooms shall be rigid type insulation with equivalent R value. Product shall be Owens Corning SOFTR™ Type 075 or equal. All seams and joints shall be taped with matching kraft paper vapor barrier tape.

D. Exterior Ductwork

1. Exterior Supply & Return Air Ductwork: All supply air and return air ductwork located outside the heated building envelope shall be insulated with 2" thick polyisocyanurate closed-cell rigid duct insulation, ASTM C 591, type IV, K=0.19), for use at temperatures up to 149 degree C (300 degree F) regardless of whether internal lining is present. Insulation shall be sloped so as to pitch water towards edge of ductwork.

2. Provide covering on all exterior insulated ductwork and equipment. Product shall be field-applied or pre-applied protective finishing and/or vapor sealing, operating within the range of -94°F (-70°C) and 300°F (149°C), jacketed with laminated, flexible, self-adhering, protective jacketing, vapor barrier and weather proofing membrane, having a high performance acrylic adhesive capable of installation with no additional mechanical attachment. Material is to be VentureClad 1577CW (5ply) Natural, White (White Membrane "WM"), or approved equal finish selected based on availability and desired final appearance of insulated system. Jacketing material is to have a maximum flame spread/smoke developed index of 10/20 per UL 723 test, a .000 water vapor permeance rating per ASTM E-96, and mold inhibitors incorporated. All products are UV stable. Fabrication and installation shall conform to the manufacturer's installation instructions and Midwest Insulation Contractors Association National Insulation Standards Manual. If there is conflicting information, manufacturer's installation instructions are to be followed.

E. Ductwork in Mechanical Rooms:

1. All ductwork exposed within the mechanical room shall be insulated with rigid duct insulation (1.5" thick for supply and return and heat reclaimed exhaust and 2" thick for outdoor air ductwork) with vapor barrier, 3.0 lbs. per ft. density glass fiber with maximum K factor of 0.23 at 75 degree F mean temperature with fire retardant foil/Kraft (FSK) vapor barrier facing with a minimum R value of 6. Duct indicated as being

internally lined need not be externally insulated (except when located on roof) or if conveying outside air or part of an outdoor air or relief air plenum. For outdoor air duct and outdoor air and relief air louvers insulate with 4" of insulation with an installed R-value of 12.

F. Piping Insulation

1. All hot water, chilled water, condensate piping and glycol water piping (supply and return) shall be insulated with pipe insulation with a conductivity of 0.23 BTU-inch/HR-SF-F at 75F. Piping insulation shall be equivalent to Owens Corning Fiberglas™ SSL II with ASJ Max Paper Free polymer all service jacket.

   Minimum Insulation Thickness shall be as follows and includes glycol piping:

Pipe Service	Insulation Thickness
Hot Water Heating S&R	1.5"
Chilled Water Heating S&R	1.5"
Hot Water S&R under 1.5" diameter	1.0"
Chilled Water S&R under 1.5" diameter	1.0"
Chilled Water S&R behind chilled beam under 1.5" diameter	0.5"
Hot Water Heating S&R Outside Bldg. Thermal Envelope	2.0"
Chilled Water S&R Outside Bldg. Thermal Envelope	2.0"
Condensate Piping (not incl. chilled beams)	0.5"
Condensate Piping serving chilled beams and sensible coils	0.0"

   All domestic water feed lines to the hydronic systems shall be insulated with minimum ½" thick pipe insulation similar to that specified above.

   Provide Zeston, Proto or equal polymer fittings at all elbows and fittings. Seal all joints and seams vapor tight. For piping 2" or greater in size provide high-density crush resistant (calcium silicate blocking or equal) insulation at all hangers. Provide 14 gauge 18" insulation shields at every hanger. Vapor barrier must be maintained continuously on all piping.

2. Refrigerant vapor (suction, hot gas and evaporating liquid) piping shall be insulated with 1" thick closed cell pipe insulation as manufactured by Armorcell or equal with seams and joints cemented vapor tight. All insulation exposed to the exterior of the building shall be covered with U.V. resistant PVC jacket.

3. Provide covering on all exterior insulated piping and ductwork. Product shall be field-applied or pre-applied protective finishing and/or vapor sealing, operating within the range of -94°F (-70°C) and 300°F (149°C), jacketed with laminated, flexible, self-adhering, protective jacketing, vapor barrier and weather proofing membrane, having a high performance acrylic adhesive capable of installation with no additional mechanical attachment. Material is to be VentureClad 1577CW (5ply) Natural, White (White Membrane "WM"), or approved equal finish selected based on availability and desired final appearance of insulated system. Jacketing material is to have a maximum flame spread/smoke developed index of 10/20 per UL 723 test, a .000 water vapor permeance rating per ASTM E-96, and mold inhibitors incorporated. All products are UV stable. Fabrication and installation shall conform to the manufacturer's installation instructions and Midwest Insulation Contractors Association National Insulation

Standards Manual. If there is conflicting information, manufacturer's installation instructions are to be followed.

E. All kitchen hood exhaust ductwork shall be insulated with two (2) layers of 1-1/2" (3" total installed thickness) of Fire Master, Duct Wrap or approved equal. In addition, all fume hood exhaust ductwork transecting floors which is not enclosed within a 2-hour rated shall be insulated as specified for kitchen hood ductwork. Install per manufacturer's instructions. Support system with approved thermally isolated hangers.

F. Where specifically noted herein or noted on the drawings provide acoustical sound absorption of equipment externally wrap devices with acoustical insulation as noted herein. Acoustical insulation shall be Sound Seal #BBC-15 or approved equal composite wrap consisting of a 1" thick nonwoven pourous scrim faced quilted fiberglass absorber/decoupler that is bonded to a reinforced 1 psf loaded vinyl noise barrier. Pieces shall be custom fabricated to fit each unit with seams for service to equipment provided with Velcro seals. Product shall have a fame spread of 12.5 and a smoke developed or 19.5 and in no case shall exceed 25 flame spread & 50 smoke developed. Sound Transmission Loss ratings shall be across the full octave spectrum with an STC of no less than 27.

G. Refer to Ductwork Article for internal acoustical insulation.

2.12 HANGERS AND SUPPORTS

A. Provide seismic bracing shall be provided regardless of exceptions allowed by code for this seismic category in conformance with the Commonwealth of Massachusetts building code 780 CMR, 9th edition, Chapter 16. Contractor shall hire a seismic consultant to comply with requirements of the code. All equipment and ductwork shall be seismically supported and all piping over 2". Mechanical seismic control exceptions noted in the code for the buildings seismic category shall not apply. For the purposes of seismic design of the mechanical systems, the building shall be considered an emergency shelter.

All horizontal piping shall be supported for its entire length. Suspended piping shall have hangers located within 2 ft. 0 in. of elbows and spacing shall be reduced, where required, to support heavy groups of fittings and valves. Grinnell Figure numbers are used to establish the desired style and quality. Other equal manufacturer, as approved by the Architect-Engineer, will be acceptable. All hangers shall be UL or FM approved for the application and use.

This trade contractor shall refer to "TYPICAL HANGER LOAD RESTRICTIONS at COMPOSITE SLABS and ROOF DECK" on drawing S1.03 for the following information:

a. Hanger load limitations including associated pipe sizes.
b. Metal roof deck notes.

This trade contractor shall design, furnish, and install all supplementary steel or Unistrut systems which shall be supported only by structural steel when hanger loads exceed limitations set forth in detail "TYPICAL HANGER LOAD RESTRICTIONS at COMPOSITE SLABS and ROOF DECK" on drawing S1.03.

"Sammy" hanger attachments are not permitted under any conditions.

Roof level:

- All loads are to be hung from structural steel framing. Loads are not to be hung from the metal roof deck.

Floor levels (Using hangers cast-in-place with composite concrete slab):

- Piping up to 3” diameter may be hung from the composite deck only to the limits indicated on the structural plan detail S1.03 – Typical Hanger Load Restrictions at Composite Slabs and Roof Deck, otherwise this contractor must provide and design secondary steel or Unistrut system supported from the structural beams.
- 4” diameter piping, and larger, are to be hung directly from structural steel framing.
- Hangers supporting loads other than piping shall be limited to 100 pound per hanger. Loads exceeding 100 pounds are to be reviewed by SER. Spacing of hangers are to be at least 24” from adjacent hangers, otherwise hangers are to be reviewed by SER.

In Mechanical Rooms and other similar areas, where concentrations of piping occur, all piping larger than 4” diameter shall be hung directly from structural steel framing.

B. Maximum spacing of hangers and supports shall be as follows:

1. Steel Pipe: 1-1/2 in. and smaller - 6 ft. 0 in.

2. Steel Pipe: 2 in. to 8 in. - 8 ft. 0 in.

3. Copper Tube: 1-1/4 in. and smaller - 5 ft. 0 in.

4. Copper Tube: 1-1/2 in. and larger - 8 ft. 0 in.

C. Pipe attachments shall be as follows:

1. All piping up to 2 in. diameter shall be supported using pipe rings or bands.

2. All systems 2-1/2 in. to 6 in. pipe sizes and
insulated pipe 1-1/2 in. and smaller - Grinnell Figure 260 adjustable clevis type.

3. All systems, bare or insulated pipe 6 in. and larger - Grinnell Figure 174 or 181 adjustable swivel roll type.

4. All systems, where overhead space is limited and pipes are close to underside of beams or slabs - Grinnell Figure 171 double rod roll hanger. Pipe installed on rack supports shall be supported on pipe roll chairs or stands equal to Grinnell Figure 175 or Figure 271.

5. All vertical drops of pipe 2-1/2 in. and larger shall be supported from the floor, including all pump suction and discharge piping.

6. Pipe attachments in metal to metal contact with copper and brass pipe shall be copper plated or PVC coated.

7. On all insulated pipes, provide attachments sized for outside diameter of insulation to permit insulation to pass through hanger. Include pipe covering protection shields at all hangers.

D. Supporting rods for hangers shall be adjustable, threaded with locknuts sized as follows:

1. Pipe: 2 in. and smaller - 3/8 in.

2-1/2 in. to 3-1/2 in. - 1/2 in.
4 in. and 5 in. - 5/8 in.
6 in. - 3/4 in.
8 in. to 12 in. - 7/8 in.

2. Where double rod hangers are used, the rod size may be reduced one (1) size below the above sizes.

E. Hanger rods shall be secured to building by one of the following approved structural attachments:

1. To concrete structure - use inserts, Grinnell Figure 28, galvanized steel. Where additional supports are needed after concrete work is completed or where required in solid masonry, use self-drilling inserts equal to Phillips "Red Head" or expansion shields equal to Grinnell Figure 117. Cadmium plated piping 10 in. and larger is to be supported from wall, floor, or steel structure.

2. To structural steel beams for pipes 2-1/2 in. to 5 in. - by beam clamps, Grinnell Figure 229, 265, or 267; 6 in. to 10 in. by bolted and welded beam attachments - Grinnell Figure 66 or 252. For pipes 2 in. and smaller, use malleable iron C-type beam clamps with retaining clip, Grinnell Figure 87; all piping is to be hung from the top chord of all steel joists. All piping 4 in. and larger shall be supported from 2 in. angle iron spanning between two (2) joists to spread loading. For joists, pipes and/or supplemental support steel must be attached to top of joist at panel points.

F. Pipes running along walls or close to floor shall be supported as follows:

1. Piping along walls may have hanger rods supported from welded steel brackets, Grinnell Figure 195, or in lieu of the above, for 4 in. and larger, may rest on adjustable roll stands supported by welded channel or I-beam wall brackets.

2. 2 in. and smaller - supported from floor on legs of angle iron, channels, or pipe legs.

3. 2-1/2 in. to 4 in. - adjustable pipe saddles, Grinnell Figure 264, supported from floor to pipe legs.

3. 4 in. and larger - pipe roll and plate, Grinnell Figure 277 supported as masonry piers and shimmed to provide proper pitch as required, or Grinnell Figure 276 adjustable pipe roll stands supported on masonry piers, welded steel channels, or I-beams.

G. Groups of horizontal pipe 3 in. and smaller, running at the same elevation, may be supported by means of vertical hangers and horizontal angles, channels, or "Unistrut" on which pipes shall rest and be held in alignment with suitable pipe clamps. Building attachments must be sized for total load of all pipes. Details of such hangers must first be approved by the Architect-Engineer. No contact between dissimilar metal is permitted.

H. Equipment Supports:

1. All floor mounted machinery and equipment shall be installed on minimum 4 in. thick concrete housekeeping bases with top edge of base chamfered at a 45 degree angle. Bases will be provided under other Sections of these Specifications. Furnish scaled layouts of all required bases, with dimensions of bases, and location to column center lines. Furnish templates, anchor bolts, and accessories necessary for base construction.

2. Furnish and install all supplementary steel, channels, and supports required for the proper installation, mounting, and support of all equipment. Supplementary steel and channels shall be firmly connected to the building construction.

3. The type and size of the supporting channels and supplementary steel shall be of sufficient strength and size to allow only a minimum deflection in conformance with the manufacturer's requirements for loading.

4. All supplementary steel and channels shall be installed in a neat and workmanlike manner parallel at the walls, floor, and ceiling construction. All turns shall be made with 90 degree and 45 degree fittings, as required to suit the construction and installation conditions. Provide factory-fabricated tank saddles for tanks mounted on steel stands.

5. Where ceiling mounting is indicated or specified, use suspended platform or hangers, brackets, or shelf, whichever is most suitable for equipment and its location. Construct structural steel members, steel plates, rods, as required; brace and fasten to building structure or to inserts as approved.

I. Rooftop pipe support shall be similar to Portable Pipe Hangers item number PP10 w/roller. Base Material: Injection molded high impact polypropylene with UV-inhibitors and Antioxidants. Hardware: Nuts, Washers, Rod and Roller: Hot Dip Galvanized. Coordinate with roofer prior to installation."

J. Rooftop ductwork shall be supported on a rail support system by Roof-Pro model #RP-D or equal by Uni-Strut. Ductwork associated with the stair tower pressurization systems must be seismically anchored on a rigid system affixed to building steel.

K. Rooftop condensing units not shown anchored on structural platforms shall be set on fully flashed roof curbs and be fixed on a rail support system by Roof-Pro model #PF-1-T or equal by Uni-Strut. Supports system shall be anchored to flashed roof curbs with gasketed connections so as to prohibit water infiltration of the flashed curb.

2.13 PIPE SLEEVES AND ESCUTCHEONS

A. Standard IPS steel or wrought iron sleeves shall be provided wherever exposed pipes pass through masonry walls or partitions. Pipe sleeves are to be two (2) pipe sizes larger than line size. On insulated piping, sleeves shall be sized to allow insulation to pass through the sleeve without gouging. Within continuous vertical enclosed pipe chases, sleeves through floors may be 24 gauge galvanized sheet steel in lieu of iron pipe.

B. Iron pipe sleeves shall be provided through "wet" floors (such as kitchens, toilets, janitor's closets) and shall be extended 1 in. above finished floors. Sheet metal screws may be used in other locations and shall be cut flush with floor. Pipe sleeves in walls

shall be flush with face of wall both sides. Pipe sleeves through outside walls must be caulked watertight or installed with Eclipse flanged service entrance sets.

C. Provide escutcheons equal to Grinnell Figure 10 or Figure 13, chrome plated, at all locations (except inside unfinished mechanical equipment rooms and enclosed pipe chases) wherever exposed bare pipes 4 in. or smaller pass through walls, floors, or ceilings.

2.14 VALVES

A. All valves shall be of a design, which the manufacturer lists for service and shall be of the materials allowed by the latest edition of the ASME Code for pressure piping for the pressure and temperature contemplated, unless higher grade or quality is specified herein. All valves shall be of the same manufacturer except for special applications.

B. The system shall be supplied with valves in all branch mains and risers, at all pumps, tanks, reducing and control valves, heating and cooling surfaces and at all apparatus; so located, arranged and operated as to give complete shut-off. Except where flanged valves are used, each connection to equipment shall be made with screwed or flanged unions on the equipment side of the valves.

C. All valves 2” in diameter and smaller shall be bronze with bronze bodies. Valves 2-1/2” in diameter and over shall have iron bodies with bronze trim (except where otherwise noted).

D. Ball valves shall be full port bronze body, bronze or stainless steel ball and stem, Teflon seats and seals, threaded ends, 400 psig cold W.O.G. by Apollo, Watts or Jenkins.

E. All bronze and iron valves shall be furnished with Teflon impregnated packing.

F. Butterfly valves shall only be allowed on piping 3” and larger and shall be tight shut- off type with angle/worm gear handle mechanism with position marker.

G. All valves on PVC piping systems shall be PVC full port ball type.

H. Provide valves of the type as shown on the drawings as specified herein and as scheduled:

Service	Valve Type	Rating	Remarks
Water	Ball	400 W.O.G.	all sizes
Water Throttling	Globe	200	3” and larger
Water Shut-off & Throtl.	Butterfly	200	3” and larger
Drain Valves	Ball	200 W.O.G.	Hose end & cap

2.15 ELECTRIC CABINET & BASEBOARD HEATERS

A. Electric heaters shall be factory assembled for surface mount field installation. Enclosures shall be 16-gauge steel with corrosion resistant finish; color selection shall be by Architect. Cabinet and unit heaters shall be Berko, Qmark, Electromode or equal.

B. Coils shall be single terminal, long life electrical fin tube with helical coiled fins. Fan shall be either squirrel cage type or propeller. Provide automatic reset thermal overload protector, integral tamper resistant thermostat, fan speed switch and disconnect switch. Provide EMS interface package for EMS operation where noted or required elsewhere by the specification or on the plans.

2.16 VAV & EVAV TERMINALS

A. Provide variable air volume (VAV) terminals as scheduled and shown on the drawings and specified herein. Units shall be manufactured by Price, Titus, Nailor or approved equal. All terminals shall be certified under ARI Standard 880-94. Physical size and dimension of box and sound criteria is critical to acceptance as an approved equal.

B. The terminal casing shall be constructed of minimum 22 gauge galvanized steel, internally lined with 1” hospital grade closed cell insulation with moisture resistant and anti microbial coating all complying with UL 181 and NFPA 90A. Note: EVAV’s shall not include internal liner.

C. The damper shall be constructed of heavy gauge steel with shaft rotating in bronze self-lubricating bearings. Damper shall include a synthetic seal to limit full closed damper leakage to no more than 4 CFM at a pressure difference of 1.5”w.g.

D. All boxes shall be fitted with electronic digital controls matching the building EMS including flow/velocity sensor, modulating damper motor & actuator. Fully coordinate with EMS contractor for factory or field installed controls. Refer to Automatic Temperature Controls for additional information. All box controls shall match DDC system control manufacturer.

E. For all EVAV terminals (and select VAV terminals) where scheduled to operate at a minimum airflow below pitot limits provide an Ebtron #EF-x1000-T airflow station. EVAV’s shall be ordered without there flow station with the Ebtron unit field installed

F. Hot water coils on VAV’s where scheduled shall be copper tube type with aluminum fins leak tested to 300 psi and burst tested to 2000 psi. All coils shall be tested and rated in accordance with ARI Standard 410.

2.17 FVAV DOAS TERMINALS

A. Provide fan powered series style variable air volume (FVAV) terminals configured for DOAS systems as scheduled and shown on the drawings and specified herein. Units shall be manufactured by Price, Krueger, Titus or approved equal. Physical size and dimension of box and sound criteria is critical to acceptance as an approved equal.

B. The terminal units shall be ETL listed as a complete assembly. All electrical components shall be UL listed and installed in accordance with the National Electric Code. All electrical components shall be mounted in sheet metal control enclosures. Electrical connections shall be single point.

C. Factory-assembled, externally powered horizontal fan powered terminal unit with blower, blower motor, mixing plenum and primary air damper contained in a single unit housing. Unit shall be complete with a damper assembly, flow sensor, externally mounted volume controller, collars for duct connection and all required features. Control box shall be clearly marked with an identification label that lists such information as nominal cfm, maximum and minimum factory-set airflow limits, coil type and coil hand, where applicable.

D. All boxes shall be furnished with electronic digital controls supplied by the building EMS manufacturer including flow/velocity sensor, modulating damper motor & actuator, fan relay, etc…. Fully coordinate with EMS contractor for factory installation (i.e. the controls shall be shipped to the factory for installation). Refer to Automatic Temperature Controls for additional information. All box controls shall match DDC system control manufacturer.

E. Unit Cabinet:

1. Constructed of 20-gage galvanized steel with round or rectangular inlet collar and rectangular discharge with slip and drive connection. All primary air inlet collars shall accommodate standard flex duct sizes.
2. Insulation shall meet NFPA-90A requirements for flame spread and smoke generation and UL-181 requirements for anti-erosion, corrosion and fungus properties. 1” thick insulation: Unit casing shall be lined with dual density, 1” thick, 3 lb. density fiberglass insulation that meets UL181 and NFPA-90A. Liner to have an anti-microbial coating.
3. Unit shall have four gasketed access panels, top, bottom and each side. Each access panel is to be large enough to remove or service motor/blower assembly. Each access panel is to be equipped with quick-access, tool-free snap latches that can be manually opened. The access panels shall not be blocked with any accessories like electric coils, controls enclosures, sound attenuators etc..
4. Casing to be reversible so right or left hand inlet/motor configurations can be achieved in the field by simply flipping factory supplied unit upside down.

F. Damper Assembly:

The control air damper assembly shall be constructed of heavy gauge galvanized steel with peripheral gasket, and solid steel shaft, pivoted in self-lubricating bearings. In the full closed position, air leakage past the closed damper shall not exceed 2% of the nominal catalog rating at 3"w.g. inlet static pressure, when tested in accordance with ASHRAE 130. Damper shaft shall be marked on the end to indicate damper position. Damper blade shall operate over a full 90°.

G. Fans:

Fan blower shall be constructed of steel with forward curved blades, dynamically balanced wheels and direct drive motor. Motor/blower assembly is to be mounted with 16ga support panel for added structural integrity and vibration isolation.

Motors shall be GE, ECM™ DC brushless style complete with and operated by a single phase integrated controller / inverter that operates the wound stator and sensor motor position to electronically commutate the stator. All motors shall be designed for synchronous rotation. Motor rotor shall be permanent magnet type with near zero rotor losses. Motor shall be permanently lubricated with ball bearings. Motor shall maintain a minimum of 70% efficiency over its entire operating range. Motors shall be direct coupled to the blower. Provide isolation between motor and blower assembly. Provide manual fan speed control for field adjustment of fan air flow setpoint. In addition, fan shall be provided with a speed control input to allow for control of speed via an external signal from the EMS. Speed control shall accept as standard a 0 - 10VDC or 0 - 20mA signal (as coordinated with EMS contractor for remote fan adjustment from the EMS.

H. Electrical Requirements:

Units shall have a single connection for power, and operate on 208 VAC single phase, 60 Hz power or as otherwise shown on the equipment schedule. Units shall incorporate a single point electrical and control connection for the entire unit. All electrical components shall be enclosed in a single control box with an access panel mounted on the side of the assembly. All controls shall be sealed from primary air flow. Units shall be CSA certified, ETL listed and ARI certified. Provide 24 volt control transformer. Provide unit fan and control disconnect switch.

I. Controls:

All boxes shall be furnished with electronic digital controls matching the building EMS including flow/velocity sensor, modulating damper motor & actuator, fan relay, etc…. Fully coordinate with EMS contractor for factory or field installed controls. Refer to Automatic Temperature Controls for additional information. All box controls shall match DDC system control manufacturer. Controls shall be capable of maintaining required airflow setpoints +/- 5% of the unit's capacity at any inlet pressure up to 6-in. w.g. The controllers shall be capable of resetting between factory or field-set maximum and minimum (>350 fpm inlet duct velocity) set points to satisfy the room thermostat demand.

The air flow sensor shall be of a cross configuration located at the inlet of the assembly. The sensor shall have twelve total pressure sensing ports and a center averaging chamber designed to accurately average the flow across the inlet of the assembly. Sensor shall provide accuracy within 5% with a 90° sheet metal elbow directly at the inlet of the assembly. The air flow sensor shall amplify the sensed air flow signal.

I. Accessories:
   1. Hot Water Heating Coil:
      Hot water coils shall be tested for leakage at 250 psig with the coil submerged in water and pressure tested to 349 psig at 300ºF. Coil shall be mounted in a minimum 0.030" galvanized steel casing with slip and drive discharge connections, and factory mounted on the base unit as shown on the equipment drawings. Coils shall have:
      a. Aluminum fins bonded to the copper tubes by mechanical expansion.
      b. Number of coil rows, circuits and fins per inch shall be selected to provide performance as required by the plans.
      c. Right or left-hand fittings with sweat connection sizes as indicated on plans and as coordinated in the field.
      d. Coil shall be tested and certified according to ARI Standard 410.
   2. Chilled Water Sensible Cooling Coil:
      Chilled water coils shall be tested for leakage at 250 psig with the coil submerged in water and pressure tested to 349 psig at 300ºF. Coil shall be mounted in a minimum 0.030" galvanized steel casing with slip and drive discharge connections, and factory mounted on the base unit as shown on the equipment drawings. Coils shall have:
      a. Aluminum fins bonded to the copper tubes by mechanical expansion.
      b. Number of coil rows, circuits and fins per inch shall be selected to provide performance as required by the plans.
      c. Right or left-hand fittings with sweat connection sizes as indicated on plans and as coordinated in the field.
      d. Coil shall be tested and certified according to ARI Standard 410.
      e. Coil shall have an auxiliary drain pan sloped to a drain fitting.

J. Performance:

   1. The pressure drop through the units shall not exceed scheduled values, including hot water coils.

2. Acoustical Requirement

2.1 Unit supplied shall be rated in accordance with ARI 880 certification program at the rated flow rates and pressures. The unit manufacturer shall furnish octave band sound power data for both casing radiated and discharge sound levels with the selected lining and above flow sensor, as tested per ARI Industry Standard 880-98, at the required flow rates and inlet pressures. Both Discharge and Radiated sound data shall result in room Sound Pressure levels not to exceed those listed below, with a tolerance of + 2 dB in any band for less than 20% of the units, when determined in accordance with ARI 885-98 Appendix E with the following listed assumptions:

The terminal unit shall not exceed the radiated sound power levels stated in the specified manufacturer's catalog or as follows based on 1 inch inlet static pressure and design primary airflow at 0.25 inch downstream static pressure.

Airflow	Sound Power Levels					
CFM	2	3	4	5	6	7
900	61	56	51	44	40	39
1200	62	55	48	42	39	39
1600	66	59	53	47	43	42
2000	71	63	56	51	48	48

K. For each FVAV provide four (4) complete sets (one set mounted in FVAV and 3 spare sets) of MERV 13 pleated filters.

L. As noted in the INSULATION section of this specification All FVAV's located over classrooms and other devices where noted herein or noted on the drawings provide acoustical sound absorption of equipment externally wrap devices with acoustical insulation as noted herein. Acoustical insulation shall be Sound Seal #B-20/QFA-3 or approved equal composite wrap consisting of a 1" thick nonwoven porous scrim faced quilted fiberglass absorber/decoupler that is bonded to a reinforced 1 psf loaded vinyl noise barrier. Pieces shall be custom fabricated to fit each unit (return air opening shall be uncovered) with seams for service to equipment provided with Velcro seals. Product shall have a flame spread of 12.5 and a smoke developed or 19.5 and in no case shall exceed 25 flame spread & 50 smoke developed. Sound Transmission Loss ratings shall be across the full octave spectrum with an STC of no less than 27.

2.18 VARIABLE FREQUENCY DRIVES

A. For the all equipment specified within this specification section and/or shown on the drawings, provide variable frequency drives of the characteristics described herein. Acceptable manufacturers contingent on compliance with this specification are as follows:
- Allen Bradley
- ABB
- Toshiba

B. This contractor shall furnish and install VFD's. Electrical contractor shall provide power wiring to VFD and from VFD to respective motor.

C. Unit must be capable of interfacing with the buildings energy management system to openly communicate all faults, points and operational data (i.e. fan speed, amperage draw,

wattage, etc…). Units shall be provided with required interface hardware and software and communication port (RS-485 or equal) for open protocol interface to the building EMS.

D. Input and monitoring control signals must be compatible with automatic control system. Submit acceptance and compatible letter with submittal.

E. The VFD shall comply with the latest applicable standards of ANSI, IEEE 519 and NEMA. All drives must be U.L. or E.T.L. listed.

F. The VFD shall submit harmonic calculations in accordance with IEEE 519 standards. In any event the total harmonic voltage and current distortion levels shall be no greater than 5%. Provide line reactors as required to achieve this specification.

G. The VFD shall be of the pulse width modulating design with an efficiency greater than 96% at 100% speed and load. Power factor displacement shall exceed 0.95 regardless of speed and load.

H. VFD shall be capable of receiving start/stop and modulating 4-20mA input signals. In turn the VFD shall be capable of modulating the speed of the respective motor accordingly and send 4-20mA feedback signals to the EMS system in addition to alarm conditions. VFD's shall be provided with a BacNet (type as determined by selected EMS system vendor) communication interface card for communication to the building EMS.

I. VFD shall have door-mounted controls and status indication from an LED display capable of showing as a minimum RPM, Amperage draw, elapsed operating time, frequency, etc. The door-mounted keypad shall allow you to access these features and override the input signal.

J. For fans, not part of packaged equipment such as RTU's, VFD's shall come equipped with a true bypass circuit which shall allow the user to bypass all the internal circuitry of the VFD and place the respective motor in manual operation with a Bypass-Auto, Hand-Off selector switch. The bypass device shall be downstream of motor protection over current protection fuses or breakers.

K. Testing, checkout and start-up of the VFD equipment shall be performed under the technical direction of the manufacturer's service engineer. During setup all critical speeds shall be locked out to protect connected equipment. Under no circumstances are any portions of the drive system to be energized without authorization from the manufacturer's representative.

L. Contractor shall provide all supplemental steel, supports, rods and hangers necessary to hang or mount the VFD's.

2.19 EXHAUST FANS

A. Exhaust fans shall be of the type and capacity shown on the Drawings; Greenheck, Carnes, Penn or equal. Fans shall be tested in accordance with AMCA and bear the AMCA Certified Performance Ratings Seal; fans shall be UL Listed. Provide all with disconnect switches (NEMA 3R weatherproof where exposed on roof).

B. Centrifugal roof exhaust fans shall be heavy gauge aluminum mounted on a rigid support structure to provide minimal resistance to airflow and minimal noise generation. Fan wheel shall be of the aluminum backward curved centrifugal type belt driven. Motorized backdraft

dampers shall be provided on each roof exhaust fan. Backdraft damper shall be interlocked with operation of exhaust fan to open fully, or modulate as specified, upon fan activation and close completely when fan is disabled. If dampers are not shown connected on the electrical plans, this Contractor shall hire the project electrician to wire the dampers to interlock with fan operation. Fans shall come with a factory wired and mounted disconnect switch.

C. Centrifugal blower fans for stair tower pressurization shall be UL 705 rated and shall be constructed of heavy gauge galvanized steel mounted on a rigid support structure. Fan blades shall be non-overloading backward incline type heavy gauge welded steel construction. Provide weather cover, vibration pads, flexible inlet connector, backdraft damper. All components shall be factory painted with a baked enamel finish. Provide pressure class fan as required by the application. Provide 1.5 times the required belts for the performance required with no less than 2 belts. Provide a motor with a service factor of 1.15 with motor selected to operate below its rated horsepower.

D. Ceiling exhaust fans shall be direct drive centrifugal type. Motor and fan shall be removable from housing; motor shall have ball bearings. Housings shall be steel with acoustic insulation; provide ceiling grille. Provide factory mounted disconnect switch and backdraft dampers. Provide hanging vibration isolators. For fans in emergency electrical rooms and elevator machine rooms provide 1-1/2 hour ceiling radiation fire damper at fan grille.

E. For kitchen hood exhaust fans provide an upblast fan as scheduled rated for kitchen hood duty. Fan shall all be U.L. 762 listed and NFPA 96 compliant. Blower fans shall be constructed of heavy gauge galvanized steel mounted on a rigid support structure. Fan blades shall be non-overloading self cleaning type heavy gauge galvanized welded steel construction. Provide motor weather cover and OSHA guard. All components shall be factory painted with a baked enamel finish. Fan blade shall be spark resistant. Provide pressure class fan as required by the application. Provide a polypropylene or equal side mount grease trap filled with grease absorbent material. Provide two (2) spare absorbant material replacement segments per fan.

F. Utility blower fans shall be constructed of heavy gauge galvanized steel mounted on a rigid support structure. Fan blades shall be non-overloading backward incline type heavy gauge welded steel construction. Provide weather cover, vibration pads, flexible inlet connector, backdraft damper. All components shall be factory painted with a baked enamel finish. Fan blade shall be spark resistant and motor shall be explosion proof. Provide pressure class fan as required by the application.

G. High Plume Hood Fans

1. Provide high plume fume hood fans where scheduled on the drawings similar to Greenheck Vektor-H or approved equal. Provide laboratory rated chemical resistant fan. Performance ratings shall conform to AMCA standard 211 and 311. Fan shall be licensed to bear the AMCA ratings seal for both sound and air performance. Classification for Spark Resistant Construction shall conform to AMCA 99. Fan shall be direct drive or belt drive, be equipped with #316 stainless steel lifting lugs and fasteners and be designed for a minimum of 125 MPH wind loading, without the use of guy wires. All fan and system components (fan, nozzle, windband and plenum) shall be corrosion resistant coated with a two part electrostatically applied and baked, sustainable, corrosion resistant coating system with a minimum total thickness of 6 mils shall exceed 4,000 hour ASTM B117 Salt Spray Resistance. Standard finish color to be gray.
2. Fan housing to be aerodynamically designed with high-efficiency inlet, engineered to

reduce incoming air turbulence. Fan housing shall be welded steel with similar corrosion resistant coating. No uncoated metal fan parts shall be acceptable. A high velocity conical discharge nozzle shall be supplied by the fan manufacturer and be designed to efficiently handle an outlet velocity of up to 6000 FPM. Discharge stack caps or hinged covers, impeding exhaust flow shall not be permitted. Provide housing drain for removal of rain and condensation.

3. A bolted and gasketed access door shall be supplied in the fan housing allowing for impeller inspection or removal of impeller, shaft and bearings without removal of the fan housing. Fan impeller shall be centrifugal, backward inclined, with non-stall characteristics. The impeller shall be electronically balanced both statically and dynamically per AMCA Standard 204. Fan impeller shall be manufactured of aluminum (AMCA type B spark resistant), fully welded and must meet corrosion resistant coating. Provide access panel for duct and fan cleaning.
4. For variable volume systems a bypass air plenum shall be provided as shown on drawings. The plenum shall be equipped with a bypass air damper and intake air hood with bird screen for introducing outside air at roof level upstream of the fan. The plenum shall be constructed of fully welded steel, meet specification section for corrosion resistant coating, and mount on roof curb as shown on the project drawings. The bypass air plenum shall be mounted on factory fabricated roof curb provided by the fan manufacturer. Bypass air dampers shall be opposed-blade design, and coated with up to 4 mils of Hi-Pro Polyester resin, electrostatically applied and baked. A fan isolation damper two position actuated, fabricated of steel or aluminum and coated with minimum 4 mils of Hi-Pro Polyester resin, electrostatically applied and baked, shall be provided. Damper shall be rated for the application.
5. Exhaust system manufacturer shall supply a structural support curb for the plenum, of specified height, as shown on the drawings or required by code or indicated herein. Laboratory hoods shall have a minimum outlet height of 10 feet. Curb shall be fabricated of a minimum of 14 gauge corrosion resistant coated steel and structurally reinforced. Seismic certification requires a minimum of 12 gauge corrosion resistant coated steel and structurally reinforced roof curb be provided. Curbs shall be insulated. When properly anchored to the roof structure, the standard curb / plenum / blower assembly shall withstand wind loads of up to 125 mph without additional structural support.
6. Motors shall be premium efficiency, inverter rated standard NEMA frame, 1800 or 3600 RPM, TEFC with a 1.15 service factor. A factory-mounted NEMA 3R disconnect switch shall be provided for each fan. Motor maintenance shall be accomplished without fan impeller removal or requiring maintenance personnel to access the contaminated exhaust components.
7. Drive belts and sheaves shall be sized for 200% of the motor horsepower, and shall be readily and easily accessible for service, if required. Drive shall consist of a minimum of two belts under all circumstances.
8. Fan shaft to be turned and polished of 316 stainless steel coated with corrosion resistant coating. Fan shaft bearings shall be Air Handling Quality, ball or roller pillow block type and be sized for an L-10 life of no less than 100,000 hours. Bearings shall be fixed to the fan shaft using concentric mounting locking collars, which reduce vibration, increase service life, and improve serviceability. Bearings that use set screws shall not be allowed. All shaft bearings shall have extended lube lines with zerk fittings.
9. Install fans in accordance with manufacturer's instructions. Provide variable frequency drive with true H-O-A bypass circuit for each fan compatible with utility requirements.

H. Fans specified have critical sound performance criteria and configuration requirements that must be adhered to. Any equal substitutions must meet or exceed the quality of the

specified unit and have sound performance at or below the levels of the specified fans. Fans shall be licensed to bear the AMCA Seal for sound and air performance.

I. Motors over ½ HP in size shall be premium efficiency type. Refer to schedules for electrical voltage & phase requirements. Provide ECM motors where scheduled. ECM motors shall be equipped with integral control transformer for 0 to 10 VDC control by EMS. Where scheduled ECM motors shall also be fitted with potentiometers for balancing.

J. Each motor on a VFD shall be provided with a shaft grounding device to harmlessly bleed potential induced shaft voltages to ground

K. Furnish H-O-A type combination disconnect and motor starters for each exhaust fan for interface to EMS. Refer to variable frequency drive section, schedules and automatic temperature controls for additional information on fan starters required (i.e. H-O-A's, VFD's, line voltage t'stats, relays, etc…. Electrical contractor to mount and wire H-O-A starters. All fans shall be furnished with disconnect switch.

L. Destratification fans as manufactured by Airius or approved equal shall be provided as scheduled and shown on the drawings. Fans shall have a multi-vane stator, PC/ABS resin flame resistant housing and EC motors for control by EMS with 0-10 Vdc signal. Unit shall be provided with a hanging bracket and 6 foot steel safety cable. Standard color selection by Architect as units shall be painted in the filed by project painting contractor section 09.91.00. Contractor shall deliver fans to painting contractor and once painted shall install fans. Units shall come with 3-year parts and labor warranty.

2.20 BOILERS

A. Furnish and install as shown on plans in accordance with all codes and authorities having jurisdiction, a condensing type boiler plant as manufactured by Lochinvar. Boiler plant specified is Lochinvar Crest, consisting of three (3) boiler modules. Acceptable alternate boiler must be capable of properly operating (including full fire) at 4" w.c. entering natural gas pressure. Each boiler shall be UL/FM approved and have a total input of 4,000 mbh each with a gross output of 3,720 MBH (dependent upon return water temperature) when fired with natural gas (total plant input 12,000,000 BTUH and 11,160,000 BTUH output). Overall plant design shall be 140°F supply water temp and 120°F return water temp. Boiler shall be capable of delivering 180°F supply water. As indicated in section 01.60.00 Product Requirements, 1.6 Owner's Proprietary Products, the Lochinvar Crest boilers are a proprietary product and no alternates shall be allowed.

B. Boiler modules shall be of natural gas-fired, condensing fire tube design with a modulating power burner and positive pressure discharge. Water tube design boilers shall not be acceptable. Each boiler shall be capable of 20:1 turndown of firing rate without loss of combustion efficiency. Heat exchanger/combustion chamber shall incorporate a helical fire tube design that will be self supporting, baffle free, and warranted to withstand thermal shock. Heat exchanger shall be ASME stamped for a working pressure not less than 150 psig. Unit shall have an ASME approved relief valve with a setting of 50 psig. Exhaust manifold shall be of corrosion resistant porcelain enameled cast iron, with 12" diameter flue connection. Exhaust manifold shall have a gravity drain for the elimination of condensation with collecting reservoir. Boilers shall not require boiler pumps as minimum system flow shall meet the minimum flow requirements of the boilers. Minimum boiler flow shall be no greater than 25 GPM. Pressure drop through any one unit shall not exceed 4.0 psig under full load. Unit shall be suitable to accept system temperatures at any point along the system design reset schedule without thermal shock or condensation restriction.

C. The flame monitoring system shall incorporate a U/L recognized combustion safeguard system utilizing interrupted spark ignition and a rectification type flame sensor. An electro-hydraulic double seated safety shutoff valve shall be an inherent part of the gas train.

D. Each boiler module shall incorporate electric probe type low water cutoff and dual over temperature protection including a manual reset in accordance with ASME section IV and CSD-1. Remote fault alarm contacts, sensor failure detection, and auxiliary contacts shall be standard equipment. Boilers shall operate on 120 volt 1 phase. Different voltage and phase configurations shall be acceptable however it shall be this sections responsibility to coordinate the change with the CMR and electrical contractor an pay all cost associated with making this change.

E. All aspects of installation of Boiler Plant shall be in strict accordance with manufacturer's instructions. Materials shall conform to all manufacturers' recommendations and shall include a Stainless-Steel AL-29-4C Positive Pressure U/L Listed Vent System. Boiler plant piping shall be field constructed of materials as specified. Each boiler shall have individually isolating shutoff valves for service and maintenance.

F. Boiler manufacturer shall supply as part of boiler package a completely integrated microprocessor-based Boiler Management System, as furnished by boiler manufacturer, to control all operation and energy input of the multiple boiler plant. The system shall be comprised of a microprocessor-based control utilizing pulse width modulation for bumpless transfer of header temperature and sequential firing. The controller shall be PID type for accurate temperature control with excellent frequency response. BMS shall provide contact closure for automatic adjustable heat start circuit for plant activation and have contact closure for auxiliary equipment such as pumps and combustion air dampers. The controller shall be fully Bacnet or Lon compatible as required by selected EMS system so that the building operator shall be capable of fully monitoring and controlling the boiler plant through the BMS front-end.

G. The BMS will operate on an adjustable inverse ratio in response to outdoor temperature to control the main header temperature outlet to +/-2F. Units shall operate with an Inverse Efficiency Curve, with known Part Load Value Efficiencies. Maximum efficiency shall be achieved at minimum firing input. Reset ratio shall be fully field adjustable from 0.3 to 3.0 in operation. The controller shall have LCD display for monitoring of all sensors and interlocks. Non-volatile backup of all control setpoint shall be internally provided as standard. Control will automatically balance operating time on each module by a first on-first off mode and provide for setback and remote alarm contacts. Connection between central BMS system and individual modules shall be twisted pair low voltage wiring to internal terminal strips for easy installation. System shall be enabled and disabled by the buildings energy management and control system as specified within this specification.

H. The pressure vessel of boiler shall carry an unconditional, non-prorated 10 year warranty against leakage due to defective materials or workmanship. The heat exchanger tubes/ combustion chamber assembly shall be warranted against failure due to thermal stress failure or condensate corrosion for a prorated five year period. All components of the boiler shall be warranted for at least one full year. A Warranty Certificate must be issued to the owner from the manufacturer and a copy of warranty be submitted for engineers approval.

I. Contractor shall provide the services of a local factory authorized representative to supervise all phases of equipment startup. A letter of compliance with all factory recommendations and installation instructions shall be submitted to the engineer with operation and maintenance instructions.

J. Provide ECM variable flow pump for each boiler programmed to be enabled when a respective boiler is called to firing, modulate to optimize temperature drop across boiler and to shutdown after a purge period once a respective boiler is disabled.

K. Provide a serviceable acid neutralizing kit for each boiler. Provide replacement limestone for three (3) full years of operation.

L. Execution:

1. Preliminary requirements: Provide the services of a Company Field Advisor of the Boiler manufacturer for the following:

   a. To assist and review the installing contractor with the assembly and erection of each Boiler. Upon completion of the Boiler assemblies, the Boiler manufacturers Company Field Advisor shall certify the proper assembly and connection of each Boiler prior to startup.

   b. The boiler manufacturers Company Field Advisor shall be Present at time of Start-up to supervise the initial firing of the Boiler(s).

   c. The boiler manufacturers Company Field Advisor shall instruct Boiler Room Operating Personnel.

2. G.C. shall provide beneath each of the new Boilers, a new poured and reinforced concrete pad at least 4 in. higher than the surrounding floor (4 in. thick), and at least 6 in. wider than the Boiler on all sides. HVAC contractor shall coordinate with GC to provide four hold down bolts of at least 5/8-in. diameter into the concrete and fastened through the base channels of the Boiler. The pad shall be reinforced with Number 4 steel reinforcement bars arranged in a 12 inch by 12 inch mesh. G.C. shall provide concrete pad however division 23.00.00 shall coordinate pad layout size and hold down locations.

3. Boiler drain valves shall be connected to the lowest water space available and shall be installed with pipe and fittings to connect the bottom Blowoff full size to drain. Furnish and install 3 inch by 1-1/2 inch eccentric reducer in the lower left or right hand tappings of the front section of each Boiler complete with a short nipple and blowoff valve installed. Each blowoff valve shall be Brass, ball type, not less than 1-1/2 inch minimum and rated equal to the pressure stamped on the Boiler and to a temperature rating of not less than 250^{o} F. and all blowdown discharges shall be arranged so as to allow the Operator to view the water that is discharged to drain. Ends of blowdown piping shall be cut at a 45^{o} Degree angle to prevent a cap or plug from being installed.

4. All boiler discharges shall be piped to floor drains or as indicated by the Consulting Engineer. Furnish and install all necessary pipe and fittings to connect the pressure relief valve discharge full size (Minimum Acceptable) to floor drain. Discharge shall be arranged so that there will be no danger of scalding Boiler room personnel in the event of a pressure relief situation. Size and arrangement of discharge piping shall be such that any pressure that may exist or develop will not reduce the relieving capacity of the relief valve below that required to protect the Boiler. All such discharge piping shall be supported by hangar or standoff to prevent the valve body from undue stress or strain.

5. Installing Contractor shall utilize capped tees at all turns in the return piping to the back section of each Boiler for cleaning of the return piping at or near each Boiler. Feedwater, makeup water and/or water treatment shall be introduced into the Boiler water through the return piping only. Provisions shall be made for the expansion and contraction of all hot water mains connected to each Boiler by providing substantial anchorage at suitable points and by providing swing joints so there will be no stress or strain transmitted to either Boiler. Stop valves shall be provided in the supply and return pipe connections to each Boiler permitting draining any Boiler without emptying the entire system.

6. After final assembly and connection, each Boiler shall be thoroughly cleaned internally following the manner described within the Boiler manufacturers installation instructions.

7. All field tests after the Boiler(s) have been installed and connected to the system shall be limited to not more than 80 PSI. Installing Contractor shall furnish all equipment, piping, labor, staging, fittings, valves, hoses and other materials and shall pay all required permits for Inspection as may be required to perform such tests as may be directed by these Contract Documents and as required by the Consulting Engineer and the State Boiler Inspector.

8. An initial Hydrostatic pressure test of 80 PSI shall be conducted on each Boiler for a period of not less than 5 hours. Tests shall be of such duration as necessary and as directed by the Consulting Engineer to ensure that the Boilers have been installed and piped correctly with no leaks or other improper operating conditions.

9. Installing Contractor shall contact and notify the State Boiler Inspector when the installation of the Boiler(s), Burner(s) and controls is substantially complete. Installing Contractor shall request an inspection of the Boilers to be conducted by the State Boiler Inspector and to have a Certificate of Inspection issued upon satisfactory inspection.

10. After receipt of certificate of Inspection, Installing Contractor shall furnish a suitable glass front frame in which to place said certificate. Frame, with Inspection certificate inserted therein, shall then be placed on or posted in a suitable location within the Boiler room in which the new Boilers have been installed.

11. Installing Contractor shall maintain all apparatus in satisfactory operating condition. Perform periodic Burner tune-up and cleaning of the Boiler fireside surfaces when dirty, provide preventative maintenance, perform turndown tests, conduct tests for Flame Safeguard, Combustion Efficiency, Draft tests, Limit Control tests and Safety Valve tests, check the ignition system and adjust, repair or replace any as necessary while the heating system is under his ownership and control and until such time as the Owner accepts the equipment, issues the Final certificate of Payment and assumes the full obligation of Ownership.

12. Installing Contractor shall note that any Warranty Service (Hereinafter specified) as may be absorbed by the authorized Service representative shall in no way absolve the Installing Contractor from any and all responsibility for the Care, Service and Preventative Maintenance for Materials furnished to this Contract, while the Heating System is under his Control, and until final acceptance by the Owner.

13. Installing Contractor shall guarantee the entire installation for a period of One (1) Year from the date of Owner Acceptance and beneficial usage by the Owner and Date of Final Payment.

K. Commissioning:

1. An authorized representative of the Boiler or Burner manufacturer shall perform the initial start-up, final adjusting and testing of the Burners and Controls in the presence of the Owners Operating Personnel. The representative shall provide 4 hours of training to the Owner on the proper operation, adjustment and routine maintenance of the boilers.

2. The process of Start-Up and Commissioning shall include Purging of the Boiler(s); Burner Operation Tests, including CO sampling, Stack Temperature(s); CO_2 sampling; Tests for Venting; Ignition Tests; Manifold Pressure Tests; Instruction to the Owner and all other such procedures as may be directed by the Consulting Engineer.

3. The final results of a Combustion Efficiency Test with all pertinent Combustion Data shall be logged onto a check sheet which shall be submitted to the Consulting Engineer to prove compliance with this section of the Specifications and for Record purposes.

4. Combustion efficiency testing shall include no less than the following:

   a. Sample and document CO_2 in the flue gas at Low and High rates of fire with recorded Gross and Net Stack Temperatures to establish stack loss value. Each Burner shall be set to operate at the overall best performance and combustion efficiency for which the equipment is designed and capable of.

   b. Adjustment and checkout of all aquastat controls, limits, switches, operating controls, low water cutoff devices, low voltage step control relays, combustion controls, and all Lockout conditions.

   c. He shall supervise purging of the Boiler(s). All required tests for proper venting which shall include setting and adjusting the Boiler outlet damper to the Boiler manufacturers specifications.

   d. Provide instruction to the Owners Operating Personnel in the procedures to resolve a "Lockout" condition. Operating personnel shall also be instructed in the Operation and routine daily maintenance of the Burner, Combustion Controls, Multiple Boiler Reset Control System and controls during the lightoff process. The Owner shall arrange to have the personnel who require training to be present at the Lightoff.

5. Factory Authorized Burner Service representative shall provide the initial Burner lightoff and One (1) Year of Warranty Burner service. This requirement shall not be waived, nor shall the responsibility for the Service Contract be assumed by any other party unless previously approved by the Consulting Engineer in writing.

6. Burner manufacturers service representative shall furnish One (1) Year of Warranty Burner Service on the Burner(s) and Control(s) which shall commence from the Date of Original Lightoff and shall continue Warranty Burner Service coverage up to and including the First Anniversary of Burner Lightoff.

7. Warranty burner service shall include labor and materials to replace any parts or controls, which might fail in service as the result of a defect in materials or manufacture. Normal wear and tear on parts as the result of daily operation will not be included as "no charge" items (nozzles, ignitors, etc.) and other such devices, which may require

replacement as the result of operation during the Warranty Service Contract shall not be included. Preventative maintenance, in the form of yearly tune-up and bi-yearly cleanings and adjustments shall be the responsibility of the Installing Contractor throughout the duration of the Warranty Contract while the equipment is under his control. Preventative maintenance, cleaning and routine adjustments shall not be performed by the warranty service Contractor but by the Owners obligated Service Company.

8. Refer to 3 year parts and labor warranty requirement for this equipment elsewhere in the spec.

2.21 FLUE & GENERATOR VENTING

A. Furnish and install, where shown on the Drawings boiler flue and generator venting as manufactured by Metal Fab, Heat Fab or Pro Tech Systems. Refer to specification section on Boilers for additional flue venting requirements for boilers. Coordinate with electrical sub and generator vendor for additional requirements for generator.

B. For heating and domestic hot water boiler flue vent exhaust venting provide material as shown on the plans, Category IV. Materials shall conform to all manufacturer's recommendations and shall be constructed of AL-29-4C Stainless Steel Positive Pressure U/L 1738 Listed Vent System. Inner liner shall be AL29-4C and outer wrapper shall be 430 grade Stainless Steel. Mineral fiber insulation shall be provided between inner and outer sections.

C. Provide all components required for complete system. Venting systems including, but not limited to, pipe sections, tees and elbows, drains, cleanouts, supports, variable lengths, ventilated roof thimble assembly, stack cones. All components exposed to the weather shall be constructed of stainless steel.

D. On combustion air intakes for direct vented units double wall type B-vent may be used for the combustion air intake in lieu of insulated round ductwork or other product as approved by the boiler manufacturer.

E. All boiler and generator flue venting shall be installed, joined and supported in accordance with the manufacturer's published installation instructions.

F. All venting work must be done by a Massachusetts licensed plumber or gas fitter.

G. Generator flue venting shall be Metal-Fab model #IPIC-1 or approved equal and shall be rated for a positive pressure up to 60” w.g. The flue venting shall have a 304 stainless steel casing with a 304 stainless steel flue vent liner. The interstitial space shall be insulated with 1” ceramic insulation. The temperature rating for an intermittent appliance shall be 1800˚F. Provide a self-opening counterweighted stack cap flapper at top of stack and a relief vent in horizontal at base of stack.

H. Provide generator exhaust expansion joints in each generator pipe as required of a size matching the exhaust pipe size or as otherwise indicated on the drawings. Expansion joints shall be bellows style having schedule 40 carbon steel beveled cut weld ends attaching to a bellows constructed of single-ply #321 stainless steel. Expansion compensator shall be rated for generator exhaust and be capable of supporting pressure up to 50 psig and temperatures up to 1,200°F. Units shall be capable of and installed such that they will support up to 2” of axial compression and 1” of axial extension at a starting/installed

temperature of 70°F. Bellows shall be properly installed, supported, guided and anchored as recommended by the manufacturer. Acceptable manufactures shall be Bellows Xhaust by Flex-Hose Co., Inc., DME Incorporated or Hyspan Precision Products, Inc.

I. Upon completion of work, all steel generator exhaust piping shall be cleaned and primed and painted with 2 coats of high temperature paint.

2.22 SPECIALTIES

A. See also valve and other sections for additional information.

B. Multi-Purpose Valve – At each pump, Taco model MPV (multi-purpose valve) combination non-slam check valve, globe balancing valve and shut-off valve with calibrated pressure taps as manufactured by Taco or Bell & Gossett. Furnish calibrated meter to Owner upon completion of project. Note:
   1. On ECM pumps and VFD pumps, this device shall be fixed in the 100% open position and is only intended to function as a physical balancing check element and non-slam check valve.
   2. MPV is not required on skid mounted pump sets specified with check and isolation valves.
   3. On smaller pumps 10 GPM and below, in lieu of MPV provide a circuit setter balancing valve, non-slam check valve and ball valve shut-off.

C. Swing Check – Bronze body, 125 W.S.P., 200 W.O.G.

D. Strainers – Strainers shall be iron body 'Y' type with stainless steel strainers, 250-psig steam and 400 W.O.G. Provide ball valve with hose bib for blow down similar to Watts # B-6000-CC on all strainers larger than 1.25".

E. Dielectric unions – Provide where joining to dissimilar metals, Watts series #3000 or approved equal.

F. Air Separators – Provide Air Separators for the hot water no smaller than the pipe size or larger as shown on the drawings or to insure the peak flow rate is within the products maximum recommended flow rate. Unit shall be of a fully coalescing type.

   1. For system, HX, CH-1 air separators, other than the boiler decoupler, provide Spriotherm Spirovent or approved equal microbubble separator complete with quick air release vent. On sizes allowing such, provide drain port with valve and hose bib.

   2. For the central plant provide boiler system decoupler provide a Spirovent Quad VDX series or equal air eliminator, dirt separator, low less header/decoupler with quick air release and drain valve. Unit shall be of the following construction:

      a. Separator shall be fabricated steel, rated for 150 psig working pressure, stamped and registered in accordance with ASME Section VIII, Division 1 for unfired pressure vessels.

      b. Vessel shall include one chamber above the higher nozzle set for air elimination, one below the lower nozzle set for dirt separation, and one between the upper and lower nozzle sets for hydraulic separation. The vessel diameter, height above and below the nozzles, and distance between the nozzles must be equal to the basis of design.

c. Units shall include an internal medium bundle filling the entire vessel. The bundle shall consist of a copper core tube with continuous wound copper medium permanently affixed to the core.

d. Each separator shall have a separate venting chamber to prevent system contaminants from interrupting venting operation. The venting chamber shall employ an integral full port float actuated brass venting mechanism.

e. Air elimination performance shall be capable of removing 100% of the free air, 100% of the entrained air, and up to 99.6% of the dissolved air in the system fluid.

f. Dirt separation performance shall be capable of removing 80% of particles 30 micron and larger within 100 passes.

g. The warranty period shall be a non-prorated period of 36 months from date of purchase

G. Air Vents – Provide automatic air vents at all high points within the system and at all coils. Air vents shall be Sparco model #FV 147A. Vents shall be piped to nearest floor drain.

H. Water pressure reducing valves – Provide water pressure reducing valve for each water feed to the heating water systems. Valve shall be similar to Watts #U5 with strainer and pressure gauge.

I. Balancing Valves – Provide calibrated balancing valves where shown on the drawings and as specified herein, Taco model #ACUF circuit setters. Provide one at each location: 1) at each individual boiler return line; 2) at every water coil; 3) at every baseboard branch, unit heater and cabinet heater; 4) at every fan coil unit. In addition, contractor shall furnish to the Owner a Differential Gauge meter Taco model #789 with durable carrying case and hose connections.

J. Automatic Flow Balancing/Limiter:

On all chilled beams and displacement chilled beam coils, provide pressure independent automated flow limiters similar to Griswold #3K02F series or approved equal.
Unit shall have the capability to measure flow. If other designs cannot measure flow with one unit, a separate low energy loss, flow measuring venturi shall be incorporated on the outlet side of the automatic flow limiter.
Shall have setter valve functionality to allow for control valve stroke optimization.
Automatic flow limiting cartridge(s) will be made of stainless steel. No brass or plastic components allowed.
Flow rate accuracy will be +/- 5% of design flow rate.
Shall be of a pressure independent, clog resistant design and shall have an accessible and replaceable cartridge.
Valve cartridge shall have a single spring range of 2-32 psig, up to ASHRAE recommended maximum GPM. For a typical 2 beam classroom installation a 2 GPM unit would be required similar to Griswold #3K02F series or approved equal. Units with strainers and drain valves shall be acceptable so long as accessories meet the intent of the design for these devices.
The flow rate (GPM) shall be factory preset and not field adjustable unless a cartridge is replaced.
Cartridges shall be easily removable from valve body without disturbing existing piping.

K. Expansion Compensators – Provide Metraflex Metraloop Joints or approved equal at building expansion joints and seismic separation joints within building as well as elsewhere for expansion where shown on plans along with anchors and guides. For pipe expansion only, and where space for Metraloop style is not available provide housed expansion compensators with associated pipe alignment guides and anchors where shown on the drawings. Housed compensators shall have double wall stainless steel bellows housed in carbon steel enclosure as manufactured by Metraflex, Senior Flexonics or approved equal.

L. Refer to System Water Treatment Article for shot feeders.

M. Provide an automatic glycol system feeder pump with 18-gallon tank for each RTU Heat Exchanger loop and Chiller chilled and hot water loop system (total of 3) which shall maintain system pressure by pumping 35% propylene glycol into the system automatically as pressure dictates. For system provide Wessels Company #GMP-18 18-gallon mix tank, pump, piping, pressure controller, valves, etc… or approved equal.

2.23 CENTRIFUGAL PUMPS

A. Furnish and install where shown on the plans electric motor driven pumps as scheduled and specified. Pumps shall be end-suction frame mounted type, vertical in-line or in-line type as scheduled and manufactured by Grundfos, Paco or Bell & Gossett.

B. Pumps shall have capacities as scheduled on the drawings. Pumps shall be selected to operate at or near their point of peak efficiency thus allowing for operation at capacities of approximately 25% beyond design capacity. In addition, the design impellar diameter shall be selected so that the design capacity of each pump (GPM and TDH) shall not exceed 90% of the capacity obtainable with maximum impellar diameter at the design speed for that model or as approved.

C. Main System Heating pumps and HX pumps shall be as follows:

1. Furnish and install a pre-fabricated and tested variable speed packaged pumping system to maintain constant water delivery pressure.

2. The packaged pump system shall be a standard product of a single pump manufacturer. The entire pump system including pumps and pump logic controller, shall be designed, built, and tested by the same manufacturer.

3. The complete packaged water booster pump system shall be certified and listed by UL (Category QCZJ – Packaged Pumping Systems) for conformance to U.S. and Canadian Standards.

4. The complete packaged pumping system shall be NSF61 / NSF372 Listed for drinking water and low lead requirements.

5. The packaged pump system shall be ASHRAE 90.1 – 2010 compliant without the need of a remote mounted sensor. The control logic used to simulate a remote mounted sensor shall be proportional pressure control with squared or linear adaptation. An actual flow rate or calculated flow rate based on performance curves (5^{th} order polynomial) loaded into the controller; shall be used to adjust setpoint pressure in proportional pressure control. However each unit shall be able to accept remote sensor and remote signal control.

6. All pumps shall be ANSI NSF 61 / NSF372 Listed for drinking water and low lead requirements.

7. The pumps shall be of the in-line vertical multi-stage design.

8. The head-capacity curve shall have a steady rise in head from maximum to minimum flow within the preferred operating region. The shut-off head shall be a minimum of 20% higher than the head at the best efficiency point.

9. Small Vertical In-Line Multi-Stage Pumps (Nominal flow from 3 to 125 gallons per minute) shall have the following features:

   a. The pump impellers shall be secured directly to the pump shaft by means of a splined shaft arrangement.

   b. The suction/discharge base shall have ANSI Class 250 flange or internal pipe thread (NPT) connections as determined by the pump station manufacturer.

   c. Pump Construction.

      i. Suction/discharge base, pump head, motor stool: Cast iron (Class 30)
      ii. Impellers, diffuser chambers, outer sleeve: 304 Stainless Steel
      iii. Shaft 316 or 431 Stainless Steel
      iv. Impeller wear rings: 304 Stainless Steel
      v. Shaft journals and chamber bearings: Silicon Carbide
      vi. O-rings: EPDM

      Shaft couplings for motor flange sizes 184TC and smaller shall be made of cast iron or sintered steel. Shaft couplings for motor flange sizes larger than 184TC shall be made of ductile iron (ASTM 60-40-18).

      Optional materials for the suction/discharge base and pump head shall be cast 316 stainless steel (ASTM CF-8M) resulting in all wetted parts of stainless steel.

   d. The shaft seal shall be a balanced o-ring cartridge type with the following features:

      i. Collar, Drivers, Spring: 316 Stainless Steel
      ii. Shaft Sleeve, Gland Plate: 316 Stainless Steel
      iii. Stationary Ring: Silicon Carbide
      iv. Rotating Ring: Silicon Carbide
      v. O-rings: EPDM
      vi. The Silicon Carbide shall be imbedded with graphite.

   e. Shaft seal replacement shall be possible without removal of any pump components other than the coupling guard, shaft coupling and motor. The entire cartridge shaft seal shall be removable as a one piece component. Pumps with motors equal to or larger than 15 hp (fifteen horsepower) shall have adequate space within the motor stool so that shaft seal replacement is possible without motor removal.

10. Large In-line Vertical Multi-Stage Pumps (Nominal flows from 130 to 900 gallons per minute) shall have the following features:

a. The pump impellers shall be secured directly to the smooth pump shaft by means of a split cone and nut design.

b. The suction/discharge base shall have ANSI Class 125 or Class 250 flange connections in a slip ring (rotating flange) design as indicated in the drawings or pump schedule.

c. Pump Construction.

I.	Suction/discharge base, pump head	Ductile Iron (ASTM 80-55-06)
II.	Shaft couplings, flange rings:	Ductile Iron (ASTM 80-55-06)
III.	Shaft	431 Stainless Steel
IV.	Motor Stool	Cast Iron (ASTM Class 30)
V.	Impellers, diffuser chambers, outer sleeve:	304 Stainless Steel
VI.	Impeller wear rings:	304 Stainless Steel
VII.	Intermediate Bearing Journals:	Silicon Carbide
VIII.	Intermediate Chamber Bearings:	Leadless Tin Bronze
IX.	Chamber Bushings:	Graphite Filled PTFE
X.	O-rings:	EPDM

d. The shaft seal shall be a balanced o-ring cartridge type with the following features:

I.	Collar, Drivers, Spring:	316 Stainless Steel
II.	Shaft Sleeve, Gland Plate:	316 Stainless Steel
III.	Stationary Ring:	Silicon Carbide
IV.	Rotating Ring:	Silicon Carbide
V.	O-rings:	EPDM

The Silicon Carbide shall be imbedded with graphite.

e. Shaft seal replacement shall be possible without removal of any pump components other than the coupling guard, motor couplings, motor and seal cover. The entire cartridge shaft seal shall be removable as a one-piece component. Pumps with motors equal to or larger than 15 hp (fifteen horsepower) shall have adequate space within the motor stool so that shaft seal replacement is possible without motor removal.

11. Integrated Variable Frequency Drive

a. Each motor shall be of the Integrated Variable Frequency Drive design consisting of a permanent magnet synchronous motor (ECM) and a Variable Frequency Drive (VFD) built and tested as one unit by the same manufacturer.

b. The VFD shall be of the PWM (Pulse Width Modulation) design using IGBT (Insulated Gate Bipolar Transistor) technology.

c. The VFD shall convert incoming fixed frequency three-phase AC power into a variable frequency and voltage for controlling the speed of motor. The motor current shall closely approximate a sine wave. Motor voltage shall be varied with frequency to maintain desired motor current suitable for centrifugal pump control and to eliminate the need for motor de-rating.

d. The VFD shall automatically reduce the switching frequency and/or the output voltage and frequency to the motor during periods of sustained ambient temperatures that are higher than the normal operating range. The switching frequency shall be reduced before motor speed is reduced.

e. An integral RFI filter shall be standard in the VFD.

f. The VFD shall have a minimum of two skip frequency bands which can be field adjustable.

g. The VFD shall have internal solid-state overload protection designed to trip within the range of 105-110% of rated current.

h. The integrated VFD motor shall include protection against input transients, phase imbalance, loss of AC line phase, over-voltage, under-voltage, VFD over-temperature, and motor over-temperature. Three-phase integrated VFD motors shall be capable of providing full output voltage and frequency with a voltage imbalance of up to 10%.

i. The integrated VFD motor shall have, as a minimum, the following input/output capabilities:
   i. Speed Reference Signal: 0-10 VDC, 4-20mA
   ii. Digital remote on/off
   iii. Fault Signal Relay (NC or NO)
   iv. Fieldbus communication port (RS485)

j. The motor shall be Totally Enclosed Fan Cooled (TEFC) with a standard NEMA C-Face, Class F insulation with a temperature rise no higher than Class B.

k. The cooling design of the motor and VFD shall be such that a Class B motor temperature rise is not exceeded at full rated load and speed at a minimum switching frequency of 9.0 kHz.

l. The overall efficiency of the VFD and motor must exceed NEMA Premium Efficiency.

m. Motor drive end bearings shall be adequately sized so that the minimum L10 bearing life is 20,000 hours at the minimum allowable continuous flow rate for the pump at full rated speed.

12. Pump System Controller

a. The pump system controller shall be a standard product developed and supported by the pump manufacturer.

b. The controller shall be microprocessor based capable of having software changes and updates via personal computer (notebook). The controller user interface shall have a color display with a minimum screen size of 3-1/2” x 4-5/8” for easy viewing of system status parameters and for field programming. The display shall have a back light with contrast adjustment. Password protection of system settings shall be standard.

c. The controller shall provide internal galvanic isolation to all digital and analog inputs as well as all fieldbus connections.

d. The controller shall have the ability to be connected to a battery to maintain power on controller during periods of loss of supply power.

e. The controller shall have built in data logging capability. Logged vales shall be graphically displayed on the controller and able to be exported. A minimum of 3600 samples per logged value with the following parameters available for logging:
   - Estimated flow-rate
   - Speed of pumps
   - Inlet pressure
   - Process Value (usually discharge pressure of differential pressure depending on application)
   - Power consumption
   - Controlling parameter (process value)

f. The controller shall display the following as status readings from a single display on the controller (this display shall be the default):
   - Current value of the control parameter, (typically discharge pressure)
   - Most recent existing alarm (if any)
   - System status with current operating mode
   - Status of each pump with current operating mode and rotational speed as a percentage (%)
   - Estimated flow-rate, (not requiring flow meter connection)

g. The controller shall have as a minimum the following hardware inputs and outputs:
   - Three analog inputs (4-20mA or 0-10VDC)
   - Three digital inputs
   - Two digital outputs
   - Ethernet connection
   - Field Service connection to PC for advanced programming and data logging

h. Pump system programming (field adjustable) shall include as a minimum the following:
   - Water shortage protection (analog or digital)
   - Sensor Settings (Suction, Discharge, Differential Pressure analog supply/range)
   - PI Controller (Proportional gain and Integral time) settings
   - High system pressure indication and shut-down
   - Low system pressure indication and shut-down
   - Low suction pressure/level shutdown (via digital contact)
   - Low suction pressure/level warning (via analog signal)
   - Low suction pressure/level shutdown (via analog signal)
   - Flow meter settings (if used, analog signal)

i. The system controller shall be able to accept up to seven programmable set-points via a digital input, (additional input/output module may be required).

j. The controller shall have advanced water shortage protection. When analog sensors (level or pressure) are used for water shortage protection, there shall be two indication levels. One level is for warning indication only (indication that the water level/pressure is getting lower than expected levels) and the other level is for complete system shut-down (water or level is so low that pump damage can occur). System restart after shut-down shall be manual or automatic (user selectable).

k. The system pressure set-point shall be capable of being automatically adjusted by using an external set-point influence. The set-point influence function enables the user to adjust the control parameter (typically pressure) by measuring an additional parameter. (Example: Lower the system pressure set-point based on a flow measurement to compensate for lower friction losses at lower flow rates).

l. The controller shall be capable of receiving a remote analog set-point (4-20mA or 0-10 VDC) as well as a remote system on/off (digital) signal.

m. The controller shall be able to adjust the ramp time of a change in set point on both an increase or decrease change in set point.

n. The pump system controller shall store up to 24 warning and alarms in memory. The time, date and duration of each alarm shall be recorded. A potential-free relay shall be provided for alarm notification to the building management system. The controller shall display the following alarm conditions:

High System Pressure	Low system pressure
Low suction pressure (warning and alarm)	Individual pump failure
VFD trip/failure	Loss of sensor signal (4-20 mA)
Loss of remote set-point signal (4-20mA)	External Fault

o. The pump system controller shall be mounted in a UL Type 3R rated enclosure. A self-certified NEMA enclosure rating shall not be considered equal. The entire control panel shall be UL 508 listed as an assembly. The control panel shall include a main disconnect, circuit breakers for each pump and the control circuit and control relays for alarm functions.

Control panel options shall include, but not be limited to:

Pump Run Lights	System Fault Light
Surge Arrestor	Emergency/Normal Operation Switches
Service Disconnect Switches	

Qty (9) Configurable Digital Outputs available for monitoring
Qty (7) Configurable Digital Inputs available for control

p. The controller shall be capable of receiving a redundant sensor input to function as a backup to the primary sensor (typically discharge pressure).

q. The controller shall have a pump “Test Run” feature such that pumps are switched on during periods of inactivity (system is switched to the “off” position but with electricity supply still connected). The inoperative pumps shall be switched on for a period of two to three (3-4) seconds every 24 hours, 48 hours or once per week and at specific time of day (user selectable).

r. The controller shall be capable of changing the number of pumps available to operate or have the ability limit the maximum power consumption by activation of a digital input for purposes of limited generator supplied power.

s. The controller shall be capable of displaying instantaneous power consumption (Watts or kilowatts) and cumulative energy consumption (kilowatt-hours).

t. The controller shall be capable of displaying instantaneous specific energy use (kW/gpm), (optional flow meter must be connected).

u. The actual pump performance curves (5th order polynomial) shall be loaded (software) into the pump system controller. Pump curve data shall be used for the following:

- Display and data logging of calculated flow rate (not requiring flow measurement)
- Proportional pressure control
- Pump outside of duty range protection
- Pump cascade control based on pump efficiency

v. The controller shall be capable of displaying an estimated flow-rate on the default status screen.

w. The controller shall have proportional pressure control to compensate for pipe friction loss by decreasing pressure set-point at lower flow-rates and increasing pressure set-point at higher flow-rates by using actual flow rate or calculated flow rate. Proportional pressure control that uses pump speed or power consumption only shall not be considered equal to proportional pressure control that uses actual or calculated flow rate.

x. The controller shall have the ability to communicate common field-bus protocols, (Bac-Net, Modbus) via a provided communication expansion card installed inside the controller.

y. The controller shall have Ethernet connection with a built in server allowing for connection to a network with read/write access to controller via web browser and internet.

z. The controller shall have a programmable Service Contact Field that can be populated with service contact information including: contact name, address, phone number(s) and website.

13. Sequence

a. The system controller shall operate equal capacity variable speed pumps to maintain a constant discharge pressure or differential pressure (system set-point), depending on the application. The system controller shall receive an analog signal [4-20mA] from the EMS indicating system pressure/demand. In addition, a factory installed pressure transducer on the discharge manifold shall indicate the actual system pressure.

b. Standard Cascade Control (Pumping Efficiency Based):
The pump system controller shall adjust pump speed as necessary to maintain system set-point pressure as flow demand increases. Utilizing the pump curve information (5th order polynomial), the pump system controller shall stage on additional pumps when pump hydraulic efficiency will be higher with additional pumps in operation. Exception: When the flow and head are outside the operating pump(s) allowable operating range the controller shall switch on an additional pump thus distributing flow and allowing all pump(s) to operate in allowable operating range. When the system pressure is equal to the system set-point, all pumps in operation shall reach equal operating speeds. The

pump system controller shall have field adjustable Proportional Gain and Integral time (PI) settings for system optimization.

c. The system controller shall be capable of switching pumps on and off to satisfy system demand without the use of flow switches, motor current monitors or temperature measuring devices.

d. All pumps in the system shall alternate automatically based on demand, time and fault. If flow demand is continuous (no flow shut-down does not occur), the system controller shall have the capability to alternate the pumps every 24 hours, every 48 hours or once per week. The interval and actual time of the pump change-over shall be field adjustable.

e. The system controller shall be able to control a pressure maintenance pump, (jockey pump), in the system in pressure boosting applications. The set point of the pressure maintenance pump shall be able to be any value above or below the pump system's set point. The pressure maintenance pump shall be able to be staged on as back-up pump when capacity of pump system is exceeded.

f. The system controller shall be capable of stopping pumps during periods of low-flow or zero-flow without wasting water or adding unwanted heat to the liquid. Temperature based no flow shut-down methods that have the potential to waste water and add unwanted temperature rise to the pumping fluid are not acceptable and shall not be used.

g. Standard Low Flow Stop and Energy Saving Mode
If a low or no flow shut-down is required (periods of low or zero demand) a bladder type diaphragm tank shall be installed with a pre-charge pressure of 70% of system set-point. The tank shall be piped to the discharge manifold or system piping downstream of the pump system. When only one pump is in operation the system controller shall be capable of detecting low flow (less than 10% of pump nominal flow) without the use of additional flow sensing devices. When a low flow is detected, the system controller shall increase pump speed until the discharge pressure reaches the stop pressure (system set-point plus 50% of programmed on/off band, adjustable). The pump shall remain off until the discharge pressure reaches the start pressure (system set-point minus 50% of programmed on/off band, adjustable). Upon low flow shut-down a pump shall be restarted in one of the following two ways:

Low Flow Restart: If the low flow condition still exists, the pump shall start and the speed shall again be increased until the stop pressure is reached and the pump shall again be switched off.

Normal Flow Restart: If the pump system controller determines a low flow condition no longer exists the pump shall start and the speed shall be increased until the system pressure reaches the system set-point.

14. System Construction

a. Suction and discharge manifold construction shall be in way that ensures minimal pressure drops, minimize potential for corrosion, and prevents bacteria growth at intersection of piping into the manifold. Manifold construction that includes sharp edge transitions or interconnecting piping protruding into manifold is not acceptable.

Manifold construction shall be such that water stagnation cannot exist in manifold during operation to prevent bacteria growth inside manifold.

b. The suction and discharge manifolds material shall be 316 stainless steel. Manifold connection sizes shall be as follows:

- 3 inch and smaller: Male NPT threaded
- 4 inch through 8 inch: ANSI Class 150 rotating flanges
- 10 inch and larger: ANSI Class 150 flanges

c. Pump Isolation valves shall be provided on the suction and discharge of each pump. Isolation valve sizes 2 inch and smaller shall be nickel plated brass full port ball valves. Isolation valve sizes 3 inch and larger shall be a full lug style butterfly valve. The valve disk shall be of stainless steel. The valve seat material shall be EPDM and the body shall be cast iron, coated internally and externally with fusion-bonded epoxy.

d. A spring-loaded non-slam type check valve shall be installed on the discharge of each pump. The valve shall be a wafer style type fitted between two flanges. The head loss through the check valve shall not exceed 5 psi at the pump design capacity. Check valves 1-1/2" and smaller shall have a POM composite body and poppet, a stainless steel spring with EPDM or NBR seats. Check valves 2" and larger shall have a body material of stainless steel or epoxy coated iron (fusion bonded) with an EPDM or NBR resilient seat. Spring material shall be stainless steel. Disk shall be of stainless steel or leadless bronze.

e. For systems that require a diaphragm tank, a connection of no smaller than ¾" shall be provided on the discharge manifold.

f. A pressure transducer shall be factory installed on the discharge manifold (and field installed as specified on plans see EMS). Systems with positive inlet gauge pressure shall have a factory installed pressure transducer on the suction manifold for water shortage protection. Pressure transducers shall be made of 316 stainless steel. Transducer accuracy shall be +/- 1.0% full scale with hysteresis and repeatability of no greater than 0.1% full scale. The output signal shall be 4-20 mA with a supply voltage range of 9-32 VDC.

g. A bourdon tube pressure gauge, 2.5 inch diameter, shall be placed on the suction and discharge manifolds. The gauge shall be liquid filled and have copper alloy internal parts in a stainless steel case. Gauge accuracy shall be 2/1/2 %. The gauge shall be capable of a pressure of 30% above its maximum span without requiring recalibration.

h. Systems with a flooded suction inlet or suction lift configuration shall have a factory installed water shortage protection device on the suction manifold.

i. The base frame shall be constructed of corrosion resistant 304 stainless steel. Rubber vibration dampers shall be fitted between each pumps and baseframe to minimize vibration.

j. Depending on the system size and configuration, the control panel shall be mounted in one of the following ways as shown on the drawings or as required to suit field conditions:

- On a 304 stainless steel fabricated control cabinet stand attached to the system skid.
- On a 304 stainless steel fabricated skid, separate from the main system skid
- On its own base (floor mounted with plinth)

15. Testing

    a. The tester used for testing the pump system shall be constructed and calibrated according to the requirements of hydraulic test standard ISO 9906.
    b. The entire pump station shall as a minimum be factory tested for functionality and documented results of functionality test supplied with pump station.

    Functionality testing shall include the following parameters:
    - Complete System Hydrostatic Test – 1.5 times the nameplate maximum pressure
    - No-Flow Detection Shutoff Test
    - Water Shortage Test
    - Two-Point Setpoint Performance Test.

    c. Water used for testing shall be treated with three different filtration systems to ensure only clean water is used for testing pump station.
    - 25 micron mechanical filter – removes solid parts from water
    - Activated carbon filter – keeps water clear and eliminates odor
    - Ultraviolet light system – kills all bacteria growth

16. Warranty: The warranty period shall be a non-prorated period of 24 months from date of installation, not to exceed 30 months from date of manufacture.

D. Boiler Pumps

    1. Provide split coupled vertical in-line pumps with integrated VFD similar to Grundfoss VLSE. If pumps are to be set on floor slab provide base stand. Pumps shall be capable of communicating directly with the boiler controller for star/stop and speed control. EMS shall wire to pump from boiler controller. EMS shall interface to status output.

E. Vertical and horizontal in-line pumps must be supported with seismically restrained spring vibration isolating hangers between the pump and the pipe vibration isolator.

F. Motors shall be as scheduled and noted herein premium efficiency type capable of qualifying for a utility company rebate. ECM motors shall be provided where scheduled with all packaged skid mount pumps having ECM motors. All other pumps up to an including 2 HP shall have ECM motors.

G. Each motor on a VFD shall be provided with a shaft grounding device to harmlessly bleed potential induced shaft voltages to ground

E. Provide variable speed drives on all pumps where scheduled or specified herein. Note ECM motors need not have VFD's. Refer to article Variable Frequency Drives for additional requirements.

F. Provide H-O-A Nema 1 disconnects on all pumps. Provide combination disconnect and motor starter for each pump not having an ECM motor, variable speed or integral speed drive. Coordinate coil voltage with control requirements.

2.24 UNIT & CABINET UNIT HEATERS

A. Provide hot water cabinet and unit heaters as manufactured by Modine, Rittling, Trane or approved equal. Units shall be U.L. listed. Unit shall have both vertical & horizontal deflection blades.

B. Cabinet unit heaters shall have a fully enclosed cabinet with adjustable frame for full, semi or surface mounting as required by the installation.

C. Provide baked enamel finish on unit. For cabinet unit heaters submit color selection chart for selection by Architect.

D. Furnish disconnect switch for all units. On cabinet unit heaters provide 3-speed fan speed control switch. Cabinet unit heaters shall have tamper proof fan speed switch enclosure.

2.25 SYSTEM WATER TREATMENT

A. Provide four (4) 5-gallon chemical bypass shot feeder for the hot water and chilled water system (one for each main hot water loop and each chilled water HX loop) equal to Neptune model #DBF-5HP with #FBK-5 filter bag kit and leg stands. Bag kit shall have stainless steel filter rack and 20-micron filter bag. Include three (3) spare bag replacements.

B. All systems shall be thoroughly flush with clear water and then filled with clear water and circulated for a period no less than 8 hours. Drain water, clean all strainers and then refill the hot water system with clean water and chemically treat. Any dumping of flush water containing chemicals must comply with local waste water regulations and have local AHJ approval.

C. For glycol systems, after flushing and testing, system shall be filled with a pre-mix of corrosion inhibited propylene glycol. Building, heating glycol loop serving RTU's, air handlers, etc… shall have 30% mixture and the chiller-heater primary loops shall have 35% mixture.

D. Provide three (3) automatic glycol feeders for the three (3) glycol systems (CH-1 chilled water, CH-1 hot water and Hot Water Glycol Loop). For each system provide Wessels Company #GMP-18 8-gallon mix tank, pump, piping, pressure controller, valves, etc… or approved equal

E. This Contractor shall furnish a one-year system water treatment service by a qualified water treatment and testing agency, including all chemicals required to prevent scaling and corrosion and a minimum of four (4) site visits. Chemicals used shall be approved by the boiler manufacturer. As a minimum, site visits and water testing shall include: initial system fill/start-up, one (1) month after start-up, six (6) months after start-up, and one (1) year after start-up. Provide written report to Architect-Engineer detailing initial system fill/start up test results.

2.26 VIBRATION ISOLATION AND FLEXIBLE CONNECTIONS (See also 2.27 Vibration and Seismic Control for additional information)

A. At duct connections to equipment, provide glass-fabric flexible neoprene connections with a minimum of 6 inch full length and approved by the governmental agencies having jurisdiction.

B. Hot water unit heaters and fan coil units under 2,000 CFM shall be suspended with double deflection neoprene hangers similar to Mason Industries model #HD. Units over this size shall be hung with 1.5" static defection spring hangers with seismic and thrust restraints.

C. Floor mounted pumps shall be set on a continuous rail system comprised of steel channels with double deflection neoprene pads securely mounted to a concrete base pad. Pumps shall be securely attached to the base rail system. System shall be similar to Mason Industries model #RND.

D. At suspended vertical pumps, provide 1-1/2" static deflection spring isolating pipe hangers within 3 feet of each side of pump. Isolators at inlet and outlet of pump shall be located on piping away from pump on opposite side of hangers.

E. At condensing units and condensers provide 6"x6" neoprene vibration pads at all support points as directed by the manufacturer. Pads shall be similar to Mason Industries model #WMFB composite pad of two neoprene layers sandwiching a steel shim. Paint edges of shim with 2 coats of rustproof primer. Units shall be securely bolted with rubber isolating fastener to the curb or pad.

F. At hydronic pipe connections to pumps provide twin sphere rubber and steel & Kevlar® reinforced flexible pipe connectors as manufactured by Mason Industries model #MFDEJ.

G. At pipe connections to boilers, air handlers, rooftop units, fan coil units and hot water unit heaters, provide braided stainless steel flexible pipe connectors as manufactured by Mercer Rubber Co. model #BSS or equal.

2.27 VIBRATION AND SEISMIC CONTROL (See also 2.26 for additional information)

A. Intent:

1. All mechanical equipment, piping and ductwork as noted on the equipment schedule or in the Specification shall be mounted on vibration isolators and with flexible connections to prevent the transmission of vibration and mechanically transmitted sound to the building structure. Vibration isolators shall be selected in accordance with the weight distribution so as to produce reasonably uniform deflections.
2. All isolators and isolation materials shall be of the same manufacturer and shall be certified by the manufacturer.
3. It is the intent of the seismic portion of this Specification to keep all mechanical building system components in place during a seismic event.
4. All such systems must be installed in strict accordance with seismic codes, component manufacturer's and building construction standards. Whenever a conflict occurs between the manufacturer's or construction standards, the most stringent shall apply.
5. This Specification is considered to be minimum requirements for seismic consideration and is not intended as a substitute for legislated, more stringent, national, state or local construction requirements (i.e. MA Codes, IBC Building Code, California Title 24, California OSHPD, or other requirements).
6. Any variance or non-compliance with these Specification requirements shall be corrected by the HVAC Trade Contractor in an approved manner.

7. Seismic restraints shall be designed in accordance with seismic force levels as detailed in Section H.
8. All piping shall be rigidly supported from the building structure by means of approved hangers and supports. This Contractor shall furnish and install all required auxiliary steel required for hanging of piping. Per the Structural Engineer, piping over 6" in diameter must be supported from the building structural components and not the composite steel decking. The combination steel deck and concrete was not designed to support heavy piping 8" in diameter and above. The use of "Bang-It" Cast In-Place Concrete Insert Hangers is acceptable for all HVAC piping 6" in diameter or less where structural steel is not available for hanging .

B. The work in this Section includes, but is not limited to, the following:

1. Vibration isolation for piping, ductwork and equipment.
2. Equipment isolation bases.
3. Flexible piping connections.
4. Seismic restraints for isolated equipment.
5. Seismic restraints for non-isolated equipment.
6. Certification of seismic restraint designs and installation supervision.
7. Certification of seismic attachment of housekeeping pads.
8. All mechanical systems. Equipment buried underground is excluded but entry of services through the foundation wall is included. Equipment referred to below is typical. (Equipment not listed is still included in this Specification).

   AC Units
   Air Distrib.
   VAV Boxes
   Ductwork
   Air Handling Units
   Fan Coil Units
   Air Separators
   Fans (all types)
   Boilers
   Heat Exchangers
   Cabinet Heaters
   Piping
   Pumps (all types)
   Rooftop Units and Air Handlers
   Tanks (all types)
   Unit Heaters
   Condensing Units
   Chiller/Heaters (Alternate)

C. Definitions:

1. Life Safety Systems:

a. All systems involved with fire protection including sprinkler piping, fire pumps, jockey pumps, fire pump control panels, service water supply piping, water tanks, fire dampers and smoke exhaust systems.

b. All systems involved with and/or connected to emergency power supply including all generators, transfer switches, transformers and all flowpaths to fire protection and/or emergency lighting systems.

c. All medical and life support systems.

d. Fresh air relief systems on emergency control sequence including air handlers, conduit, duct, dampers, etc.

e. All life safety equipment has an asterisk on the equipment schedule.

2. Positive Attachment: A positive attachment is defined as a cast-in anchor, a drill-in wedge anchor, a double sided beam clamp loaded perpendicular to a beam, or a welded or bolted connection to structure. Single sided "C" type beam clamps for support rods of overhead piping, ductwork, or any other equipment are not acceptable on this project as seismic anchor points.

3. Transverse Bracing: Restraint(s) applied to limit motion perpendicular to the centerline of the pipe, duct or conduit.

4. Longitudinal Bracing: Restraint(s) applied to limit motion parallel to the centerline of the pipe, duct or conduit.

D. Manufacturer's Data:

1. The manufacturer of vibration isolation and seismic restraints shall provide submittals for products as follows:

a. Descriptive Data:

(1) Catalog cuts or data sheets on vibration isolators and specific restraints detailing compliance with the Specification.

(2) Detailed schedules of flexible and rigidly mounted equipment, showing vibration isolators and seismic restraints by referencing numbered descriptive Drawings.

b. Shop Drawings:

(1) Submit fabrication details for equipment bases including dimensions, structural member sizes and support point locations.

(2) Provide all details of suspension and support for ceiling hung equipment.

(3) Where walls, floors, slabs or supplementary steel work are used for seismic restraint locations, details of acceptable attachment methods for ducts, conduit and pipe must be included and approved before the condition is accepted for installation. Restraint manufacturers' submittals must include spacing, static loads and seismic loads at all attachment and support points.

(4) Provide specific details of seismic restraints and anchors; include number, size and locations for each piece of equipment.

c. Seismic Certification and Analysis:

(1) Seismic restraint calculations must be provided for all connections of equipment to the structure. Calculations must be stamped by a registered professional engineer with at least five years of seismic design experience, licensed in the state of the job location.

(2) All restraining devices shall have a preapproval number from California OSHPD or some other recognized government agency showing maximum restraint ratings. Preapprovals based on independent testing are preferred to preapprovals based on calculations. Where preapproved devices are not available, submittals based on independent testing are preferred. Calculations (including the combining of tensile and shear loadings) to support seismic restraint designs must be stamped by a registered professional engineer with at least five years of seismic design experience and licensed in the state of the job location. Testing and calculations must include both shear and tensile loads as well as one test or analysis at 45 to the weakest mode.

(3) Analysis must indicate calculated dead loads, static seismic loads and capacity of materials utilized for connections to equipment and structure. Analysis must detail anchoring methods, bolt diameter, embedment and/or welded length. All seismic restraint devices shall be designed to accept, without failure, the forces detailed in Section H acting through the equipment center of gravity. Overturning moments may exceed forces at ground level.

E. Code and Standards Requirements:

1. Typical Applicable Codes and Standards - most recent or enforced code:

a. Massachusetts State Building Code.

b. International Mechanical Code (IMC).

c. NFPA 90A.

F. Manufacturer's Responsibility:

1. Manufacturer of vibration isolation and seismic control equipment shall have the following responsibilities:

a. Determine vibration isolation and seismic restraint sizes and locations.

b. Provide vibration isolation and seismic restraints as scheduled or specified.

c. Provide calculations and materials if required for restraint of unisolated equipment.

d. Provide installation instructions, drawings and trained field supervision to insure proper installation and performance.

G. Related Work:

1. Housekeeping Pads:

   a. Housekeeping pad reinforcement and monolithic pad attachment to the structure details and design shall be prepared by the restraint vendor if not already indicated on the Drawings.

   b. Housekeeping pads shall be coordinated with restraint vendor and sized to provide a minimum edge distance of ten (10) bolt diameters all around the outermost anchor bolt to allow development of full drill-in wedge anchor ratings. If cast-in anchors are to be used, the housekeeping pads shall be sized to accommodate
   the ACI requirements for bolt coverage and embedment.

2. Supplementary Support Steel: Contractor shall supply supplementary support steel for all equipment, piping, ductwork, etc. including roof mounted equipment, as required or specified.

3. Attachments: Contractor shall supply restraint attachment plates cast into housekeeping pads, concrete inserts, double sided beam clamps, etc. in accordance with the requirements of the vibration vendor's calculations.

H. Seismic Force Levels

1. The force levels described in the building code shall be used on this project. Mechanical seismic control exceptions noted in the code for the buildings seismic category shall not apply. For the purposes of seismic design of the mechanical systems, the building shall be considered an emergency shelter.

I. Product Intent:

1. All vibration isolators and seismic restraints described in this section shall be the product of a single manufacturer. Mason Industry's products are the basis of these Specifications; products of other manufacturers are acceptable provided their systems strictly comply with the Specification and have the approval of the specifying engineer. Submittals and certification sheets shall be in accordance with Section D.

2. For the purposes of this project, failure is defined as the discontinuance of any attachment point between equipment or structure, vertical permanent deformation greater than 1/8 in. and/or horizontal permanent deformation greater that 1/4 in.

J. Product Description: Vibration Isolators and Seismic Restraints:

1. Two (2) layers of 3/4 in. thick neoprene pad consisting of 2 in. square waffle modules separated horizontally by a 16 gauge galvanized shim. Load distribution plates shall be used as required. Pads shall be Type Super "W" as manufactured by Mason Industries, Inc.

2. Bridge-bearing neoprene mountings shall have a minimum static deflection of 0.2 in. and all directional seismic capability. The mount shall consist of a ductile iron casting containing two (2) separated and opposing molded neoprene elements. The elements shall prevent the central threaded sleeve and attachment bolt from contacting the casting during normal operation. The shock absorbing neoprene materials shall be

compounded to bridge-bearing Specifications. Mountings shall have an Anchorage Preapproval "R" Number from OSHPD in the State of California verifying the maximum certified horizontal and vertical load ratings. Mountings shall be Type BR as manufactured by Mason Industries, Inc.

3. Sheet metal panels shall be bolted to the walls or supporting structure by assemblies consisting of a neoprene bushing cushioned between 2 steel sleeves. The outer sleeve prevents the sheet metal from cutting into the neoprene. Enlarge panel holes as required. Neoprene elements pass over the bushing to cushion the back panel horizontally. A steel disc covers the inside neoprene element and the inner steel sleeve is elongated to act as a stop so tightening the anchor bolts does not interfere with panel isolation in three (3) planes. Bushing assemblies can be applied to the ends of steel cross members where applicable. All neoprene shall be bridge bearing quality. Bushing assemblies shall be Type PB as manufactured by Mason Industries, Inc.

4. A one piece molded bridge bearing neoprene washer/bushing. The bushing shall surround the anchor bolt and have a flat washer face to avoid metal to metal contact. Neoprene bushings shall be Type HG as manufactured by Mason Industries, Inc.

5. Spring isolators shall be free standing and laterally stable without any housing and complete with a molded neoprene cup or 1/4 in. neoprene acoustical friction pad between the baseplate and the support. All mountings shall have leveling bolts that must be rigidly bolted to the equipment. Spring diameters shall be no less than 0.8 of the compressed height of the spring at rated load. Springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. Submittals shall include spring diameters, deflection, compressed spring height and leveling valves Type LV as manufactured by Mason Industries, Inc.

6. Restrained spring mountings shall have an SLF mounting as described in Specification 5, with a rigid housing that includes vertical limit stops to prevent spring extension when weight is removed. The housing shall serve as blocking during erection. A steel spacer shall be removed after adjustment. Installed and operating heights are equal. A minimum clearance of ½ inch shall be maintained around restraining bolds and between the housing and the spring so as not to interfere with the spring action. Limit stops shall be out of contact during normal operation. Since housings will be bolted or welded in position there must be an internal isolation pad. Housing shall be designed to resist all seismic forces. Mountings shall have Anchorage Preapproval “R” Number from OSHPD in the state of California certifying the maximum certified horizontal and vertical load ratings. Mountings shall be SLR as manufactured by Mason Industries, Inc.

7. Spring mountings as in Specification 5 built into a ductile iron or steel housing to provide all directional seismic snubbing. The snubber shall be adjustable vertically and allow a maximum of ¼ inch travel in all directions before contacting the resilient snubbing collars. Mountings shall have an Anchorage Preapproval “R” Number OSHPD in the State of California verifying the maximum certified horizontal and vertical load ratings. Mountings shall be SSLFH as manufactured by Mason Industries, Inc.

8. Air Springs shall be manufactured with upper and lower steel sections connected by a replaceable flexible nylon reinforced neoprene element. Air spring configuration shall be multiple bellows to achieve a maximum natural frequency of 3 Hz. Air Springs shall be designed for a burst pressure that is a minimum of three times the published maximum operating pressure. All air spring systems shall be connected to either the building

control air or a supplementary air supply and equipped with three (3) leveling valves to maintain leveling within plus or minus 1/8 inch. Submittals shall include natural frequency load and damping tests performed by an independent lab or acoustician. Air Springs shall be Type MT and leveling valves Type LV as manufactured by Mason Industries, Inc.

9. Restrained air spring mountings shall have an MT air spring as described in Specification 8, within a rigid housing that includes vertical limit stops to prevent air spring extension when weight is removed. The housing shall serve as blocking during erection. A steel spacer shall be removed after adjustment. Installed and operating heights are equal. A minimum clearance of ½ in. shall be maintained around restraining bolts and between the housing and the air spring so as not to interfere with the air spring action. Limit stops shall be out of contact during normal operation. Housing shall be designed to resist all seismic forces. Mountings shall be SLR-MT as manufactured by Mason Industries, Inc.

10. Hangers shall consist of rigid steel frames containing minimum 1-1/4 in. thick neoprene elements at the top and a steel spring with general characteristics as in Specification 5 seated in a steel washer reinforced neoprene cup on the bottom. The neoprene element and the cup shall have neoprene bushings projecting through the steel box. To maintain stability the boxes shall not be articulated as clevis hangers nor the neoprene element stacked on top of the spring. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30 arc from side to side before contacting the rod bushing and short circuiting the spring. Submittals shall include a hanger Drawing showing the 30 capability. Hangers shall be Type 30N as manufactured by Mason Industries, Inc.

11. Hangers shall be as described in 10, but they shall be precompressed and locked at the rated deflection by means of a resilient seismic upstop to keep the piping or equipment at a fixed elevation during installation. The hangers shall be designed with a release mechanism to free the spring after the installation is complete and the hanger is subjected to its full load. Deflection shall be clearly indicated by means of a scale. Submittals shall include a Drawing of the hanger showing the 30 degree capability. Hangers shall be Type PC30N as manufactured by Mason Industries, Inc.

12. Seismic Cable Restraints shall consist of galvanized steel aircraft cables sized to resist seismic loads with a minimum safety factor of two (2) and arranged to provide all-directional restraint. Cable end connections shall be steel assemblies that swivel to final installation angle and utilize two (2) clamping bolts to provide proper cable engagement. Cables must not be allowed to bend across sharp edges. Cable assemblies shall have an Anchorage Preapproval "R" Number from OSHPD in the State of California verifying the maximum certified load ratings. Cable assemblies shall be Type SCB at the ceiling and at the clevis bolt, SCBH between the hanger rod nut and the clevis or SCBV if clamped to a beam all as manufactured by Mason Industries, Inc.

13. Seismic solid braces shall consist of steel angles or channels to resist seismic loads with a minimum safety factor of 2 and arranged to provide all directional restraint. Seismic solid brace end connectors shall be steel assemblies that swivel to the final installation angle and utilize two through bolts to provide proper attachment. Seismic solid brace assembly shall have anchorage preapproval "R" Number from OSHPD in the state of California verifying the maximum certified load ratings. Solid seismic brace assemblies shall be Type SSB as manufactured by Mason Industries, Inc.

14. Steel angles, sized to prevent buckling, shall be clamped to pipe or equipment rods utilizing a minimum of three ductile iron clamps at each restraint location when required. Welding of support rods is not acceptable. Rod clamp assemblies shall have an Anchorage Preapproval "R" Number from OSHPD in the State of California. Rod clamp assemblies shall be Type SRC as manufactured by Mason Industries, Inc.

15. Pipe clevis cross bolt braces are required in all restraint locations. They shall be special purpose preformed channels deep enough to be held in place by bolts passing over the cross bolt. Clevis cross braces shall have an Anchorage Preapproval "R" Number from OSHPD in the State of California. Clevis cross brace shall be Type CCB as manufactured by Mason Industries, Inc.

16. All-directional seismic snubbers shall consist of interlocking steel members restrained by a one-piece molded neoprene bushing of bridge bearing neoprene. Bushing shall be replaceable and a minimum of 1/4 in. thick. Rated loadings shall not exceed 1000 psi. A minimum air gap of 1/8 in. shall be incorporated in the snubber design in all directions before contact is made between the rigid and resilient surfaces. Snubber end caps shall be removable to allow inspection of internal clearances. Neoprene bushings shall be rotated to insure no short circuits exist before systems are activated. Snubbers shall have an Anchorage Preapproval "R" Number from OSHPD in the State of California verifying the maximum certified horizontal and vertical load ratings. Snubber shall be Type Z-1225 as manufactured by Mason Industries, Inc.

17. All directional seismic snubbers shall consist of interlocking steel members restrained by shock absorbent rubber materials compounded to bridge bearing Specifications. Elastomeric materials shall be replaceable and a minimum of 3/4 in. thick. Rated loadings shall not exceed 1000 psi. Snubbers shall be manufactured with an air gap between hard and resilient material of not less than 1/8 in. nor more that 1/4 in. Snubbers shall be installed with factory set clearances. The capacity of the seismic snubber at 3/8 in. deflection shall be equal or greater than the load assigned to the mounting grouping controlled by the snubber multiplied by the applicable "G" force. Submittals shall include the load deflection curves up to ½ in. deflection in the x, y and z planes. Snubbers shall have an anchorage preapproval "R" Number from OSHPD in the state of California verifying the maximum certified horizontal and vertical load ratings. Snubbers shall be series Z-1011 as manufactured by Mason Industries, Inc.

18. Stud wedge anchors shall be manufactured from full diameter wire, not from undersized wire that is "rolled up" to create the thread. The stud anchor shall also have a safety shoulder which fully supports the wedge ring under load. The stud anchors shall have an evaluation report number from the I.C.B.O Evaluation Service, Inc. verifying its allowable loads. Drill-in stud wedge anchors shall be Type SAS as manufactured by Mason Industries, Inc.

19. Female wedge anchors are preferred in floor locations so isolators or equipment can be slid into place after the anchors are installed. Anchors shall be manufactured from full diameter wire, and shall have a safety shoulder to fully support the wedge ring under load. Female wedge anchors shall have an evaluation report number from the I.C.B.O Evaluation Service, Inc. verifying to its allowable loads. Drill-in female wedge anchors shall be Type SAB as manufactured by Mason Industries, Inc.

20. Vibration isolation manufacturer shall furnish integral structural steel bases. Rectangular bases are preferred for all equipment. Centrifugal refrigeration machines

and pump bases may be T or L shaped where space is a problem. Pump bases for split case pump shall include supports for suction and discharge elbows. All perimeter members shall be steel beams with a minimum depth equal to 1/10 of the longest dimension of the base. Base depth need not exceed 14 in. provided that the deflection and misalignment is kept within acceptable limits as determined by the manufacturer. Height saving brackets shall be employed in all mounting locations to provide a base clearance of 1 in. Bases shall be Type WF as manufactured by Mason Industries, Inc.

21. Vibration isolation manufacturer shall furnish rectangular steel concrete pouring forms for floating and inertia foundations. Bases for split case pumps shall be large enough to provide for suction and discharge elbows. Bases shall be a minimum of 1/12 of the longest dimension of the base but not less than 6 in. The base depth need not exceed 12 in. unless specifically recommended by the base manufacturer for mass or rigidity. Forms shall include minimum concrete reinforcing consisting of ½ in. bars welded in place on 6 in. centers running both ways in a layer 1-1/2 in. above the bottom. Forms shall be furnished with steel templates to hold the anchor bolts sleeves and anchors while concrete is being poured. Height saving brackets shall be employed in all mounting locations to maintain a 1 in. clearance below the base. Wooden formed bases leaving a concrete rather then a steel finish are not acceptable. Base shall be Type BMK or K as manufactured by Mason Industries, Inc.

22. Curb mounted rooftop equipment shall be mounted on spring isolation curbs. The lower member shall consist of a sheet metal Z section containing adjustable and removable steel springs that support the upper floating section. The upper frame must provide continuous support for the equipment and must be captive so as to resiliently resist wind and seismic forces. All directional neoprene snubber bushings shall be a minimum of 1/4 in. thick. Steel springs shall be laterally stable and rest on 1/4 in. thick neoprene acoustical pads. Hardware must be plated and the springs provided with a rust resistant finish. The curbs waterproofing shall consist of a continuous galvanized flexible counter flashing nailed over the lower curbs waterproofing and joined at the corners by EPDM bellows. All spring locations shall have access ports with removable waterproof covers. Lower curbs shall have provision for 2 in. of insulation. The roof curbs shall be built to seismically contain the rooftop unit. The unit must be solidly fastened to the top floating rail, and the lower Z section anchored to the roof structure. Curb shall have anchorage preapproval "R" from OSHPD in the state of California attesting to the maximum certified horizontal and vertical load ratings. Curb shall be Type RSC as manufactured by Mason Industries, Inc or approved equal.

23. Flexible spherical piping connectors shall employ peroxide cured EPDM in the covers, liners and Dacron tire cord frictioning. Solid steel rings shall be used within the raised face rubber ends to prevent pullout. Flexible cable bead wire is not acceptable. Sizes 2 in. and larger shall have two spheres reinforced with a ring between spheres to maintain shape and complete with split ductile iron or steel flanges with hooked or similar interlocks. Sizes 16 in. to 24 in. may be single sphere. Sizes 3/4 in. to 1-1/2 in. may have threaded bolted flange assemblies, one sphere and cable retention. 14 in. and smaller connectors shall be rated at 250 psi up to 190 F with a uniform drop in allowable pressure to 190 psi at 250 F. 16 in. and larger connectors are rated 180 psi at 190 F and 135 psi at 250 F. Safety factors to burst and flange pullout shall be a minimum of 3/1. All joints must have permanent markings verifying a 5 minute factory test at twice the rated pressure. Concentric reducers to the above Specifications may be substituted for equal ended expansion joints. Pipe connectors shall be installed in piping gaps equal to the length of the expansion joints under pressure. Control rods need only be used in unanchored piping locations where the manufacturer determines

the installation exceeds the pressure requirement without control rods, as control rods are not desirable in seismic work. If control rods are used, they must have 1/2 in. thick Neoprene washer bushings large enough in area to take the thrust at 1000 psi maximum on the washer area. Expansion joints shall be installed on the equipment side of the shut off valves.

Flexible pump connectors shall be installed at each base mounted pump discharge and suction connection. Connections shall be spool type multi-ply stainless steel bellows with tie rods, rated for 150 psig, Keflex type 150.

Submittals shall include two (2) test reports by independent consultants showing minimum reductions of 20 DB in vibration accelerations and 10 DB in sound pressure levels at typical blade passage frequencies on this or a similar product by the same manufacturer. All expansion joints shall be installed on the equipment side of the shut off valves. Expansion joints shall be SAFEFLEX SFDEJ, SFEJ, SFDCR or SFU and Control Rods CR as manufactured by Mason Industries, Inc.

24. Flexible stainless steel hose shall have stainless steel braid and carbon steel fittings. Sizes 3 in. and larger shall be flanged. Smaller sizes shall have male nipples. Minimum lengths shall be as tabulated:

Flanged	Male Nipples
3 x 1410 x 26	1/2 x 91-1/2 x 13
4 x 1512 x 28	3/4 x 10 2 x 14
5 x 1914 x 30	1 x 112-1/2 x 18
6 x 2016 x 32	1/4 x 12 8 x 22

Hoses shall be installed on the equipment side of the shut-off valves horizontally and parallel to the equipment shafts wherever possible. Hoses shall be Type BSS as manufactured by Mason Industries, Inc.

25. For vertical riser application more than 3 stories in height, all-directional acoustical pipe anchor, consisting of two sizes of steel tubing separated by a minimum ½ in. thick 60 durometer neoprene. Vertical restraint shall be provided by similar material arranged to prevent vertical travel in either direction. Allowable loads on the isolation material should not exceed 500 psi and the design shall be balanced for equal resistance in any direction. All-directional anchors shall be Type ADA as manufactured by Mason Industries, Inc.

26. For vertical riser application more than 3 stories in height, pipe guides shall consist of a telescopic arrangement of two sizes of steel tubing separated by a minimum ½ in. thickness of 60 durometer neoprene. The height of the guides shall be preset with a shear pin to allow vertical motion due to pipe expansion or contraction. Shear pin shall be removable and reinsertable to allow for selection of pipe movement. Guides shall be capable of ± 1-5/8 in. motion, or to meet location requirements. Pipe guides shall be Type VSG as manufactured by Mason Industries, Inc.

27. Split Wall Seals consist of two bolted pipe halves with minimum 3/4 in. thick neoprene sponge bonded to the inner faces. The seal shall be tightened around the pipe to eliminate clearance between the inner sponge face and the piping. Concrete may be packed around the seal to make it integral with the floor, wall or ceiling if the seal is not already in place around the pipe prior to the construction of the building member. Seals shall project a minimum of l in. past either face of the wall. Where temperatures

exceed 240 deg. F., 10 lb. density fiberglass may be used in lieu of the sponge. Seals shall be Type SWS as manufactured by Mason Industries, Inc.

28. The horizontal thrust restraint shall consist of a spring element in series with a neoprene molded cup as described in Specification 5 with the same deflection as specified for the mountings or hangers. The spring element shall be designed so it can be preset for thrust at the factory and adjusted in the field to allow for a maximum of 1/4 in. movement at start and stop. The assembly shall be furnished with one (1) rod and angle brackets for attachment to both the equipment and the duct work or the equipment and the structure. Horizontal restraints shall be attached at the centerline of thrust and symmetrical on either side of the unit. Horizontal thrust restraints shall be Type WBI/WBD as manufactured by Mason Industries, Inc.

29. At all other platform (no curb) mounted equipment such as condensing units and the like provide 6”x6” neoprene vibration pads at all support points and as shown on the drawings, minimum of six per unit. Pads shall be similar to Mason Industries model #WMFB composite pad of two neoprene layers sandwiching a galvanized steel shim with through hole. Exposed edges of steel shim shall be painted with 2-coats of rustproof primer. Vibration isolators shall be securely bolted to unit and structural support frame with neoprene coated stainless steel bolts, washers and nuts. If required by the equipment manufacturer, provide continuous rail vibration support systems and submit for review and approval.

K. Execution - General:

1. All vibration isolators and seismic restraint systems must be installed in strict accordance with the manufacturers written instructions and all certified submittal data.

2. Installation of vibration isolators and seismic restraints must not cause any change of position of equipment, piping or duct work resulting in stresses or misalignment.

3. No rigid connections between equipment and the building structure shall be made that degrades the noise and vibration control system herein specified.

4. The HVAC Trade Contractorshall not install any equipment, piping, duct or conduit which makes rigid connections with the building unless isolation is not specified. "Building" includes, but is not limited to, slabs, beams, columns, studs and walls.

5. Coordinate work with other trades to avoid rigid contact with the building.

6. Any conflicts with other trades which will result in rigid contact with equipment or piping due to inadequate space or other unforeseen conditions should be brought to the architects/engineers attention prior to installation. Corrective work necessitated by conflicts after installation shall be at the responsible Contractor's expense.

7. Bring to the architects/engineers attention any discrepancies between the Specifications and the field conditions or changes required due to specific equipment selection, prior to installation. Corrective work necessitated by discrepancies after installation shall be at the responsible Contractor's expense.

8. Correct, at no additional cost, all installations which are deemed defective in workmanship and materials at the Contractor's expense.

9. Overstressing of the building structure must not occur because of overhead support of equipment. Contractor must submit loads to the structural engineer of record for approval. Generally bracing may occur from:

   a. Flanges of structural beams.

   b. Upper truss cords in bar joist construction.

   c. Cast in place inserts or wedge type drill-in concrete anchors.

10. Specification 12 cable restraints shall be installed slightly slack to avoid short circuiting the isolated suspended equipment, piping or conduit.

11. Specification 12 cable assemblies are installed taut on non-isolated systems. Specification 13 seismic solid braces may be used in place of cables on rigidly attached systems only.

12. At locations where Specification 12 or 13 restraints are located, the support rods must be braced when necessary to accept compressive loads with Specification 14 braces.

13. At all locations where Specification 12 or 13 restraints are attached to pipe clevis's, the clevis cross bolt must be reinforced with Specification type 15 braces.

14. Drill-in concrete anchors for ceiling and wall installation shall be Specification type 18, and Specification type 19 female wedge type for floor mounted equipment.

15. Vibration isolation manufacturer shall furnish integral structural steel bases as required. Independent steel rails are not permitted on this project.

16. Hand built elastomeric expansion joints may be used when pipe sizes exceed 24 in. or specified movements exceed Specification 23 capabilities.

17. Where piping passes through walls, floors or ceilings the vibration isolation manufacturer shall provide Specification 27 wall seals.

18. Air handling equipment and centrifugal fans shall be protected against excessive displacement which results from high air thrust in relation to the equipment weight. Horizontal thrust restraint shall be Specification type 28 (see selection guide).

19. Locate isolation hangers as near to the overhead support structure as possible.

L. Vibration Isolation of Piping:

1. Horizontal Pipe Isolation: The first three (3) pipe hangers in the main lines near the mechanical equipment shall be as described in Specification 11.

Specification 11 hangers must also be used in all transverse braced isolated locations. Brace hanger rods with SRC clamps Specification 14. Horizontal runs in all other locations throughout the building shall be isolated by hangers as described in Specification 10. Floor supported piping shall rest on isolators as described in Specification 6. Heat exchanger's and expansion tanks are considered part of the piping run. The first three (3) isolators from the isolated equipment will have the same static deflection as specified for the mountings under the connected equipment. If piping is connected to equipment located in basements and hangs from ceilings under occupied spaces the first three hangers shall have 0.75 in. deflection for pipe sizes up to and including 3 in., 1-1/2 in. deflection for pipe sizes up to and including 6 in., and 2-1/2 in. deflection thereafter. Hangers shall be located as close to the overhead structure as practical. Where piping connects to mechanical equipment install Specification 23 flexible piping connection or Specification 24 stainless hoses if 23 is not suitable for the service.

2. Riser Isolation: Risers shall be suspended from Specification 10 hangers or supported by Specification 5 mountings, anchored with Specification 25 anchors, and guided with Specification 26 sliding guides. Steel springs shall be a minimum of 0.75 in. except in those expansion locations where additional deflection is required to limit load changes to ± 25% of the initial load. Submittals must include riser diagrams and calculations showing anticipated expansion and contraction at each support point, initial and final loads on the building structure, spring deflection changes and seismic loads. Submittal data shall include certification that the riser system has been examined for excessive stresses and that none will exist in the proposed design.

M. Seismic Restraint of Piping:

1. Seismically restrain all piping listed as a, b or c below. Use Specification 12 cables if isolated. Specification 12 or 13 restraints may be used on unisolated piping.

   a. Gas piping, that is 1 in. I.D. or larger.

   b. Piping located in boiler rooms, mechanical equipment (fan) rooms, and refrigeration equipment rooms that is 1-1/4 in. I.D. and larger.

   c. All other piping 2-1/2 in. diameter and larger.

2. Transverse piping restraints shall be at 40' maximum spacing for all pipe sizes, except where lesser spacing is required to limit anchorage loads.

3. Longitudinal restraints shall be at 80' maximum spacing for all pipe sizes, except where lesser spacing is required to limit anchorage loads.

4. Where thermal expansion is a consideration, guides and anchors may be used as transverse and longitudinal restraints provided they have a capacity equal to or greater than the restraint loads in addition to the loads induced by expansion or contraction.

5. For fuel oil and all gas piping transverse restraints must be at 20 ft. maximum and longitudinal restraints at 40 ft. maximum spacing.

6. Transverse restraint for one (1) pipe section may also act as a longitudinal restraint for a pipe section of the same size connected perpendicular to it if the restraint is installed within 24 in. of the elbow or TEE or combined stresses are within allowable limits at longer distances.

7. Hold down clamps must be used to attach pipe to all trapeze members before applying restraints in a manner similar to clevis supports.

8. Branch lines may not be used to restrain main lines.

9. Cast-iron pipe of all types, glass pipe and any other pipes joined with a four band shield and clamp assembly in Zones 2B, 3 and 4 shall be braced as in sections 3.02.C.2 and 3. For Zones 0, 1 and 2A, 2 band clamps may be used with reduced spacings of ½ of those listed in sections 3.02.C.2 and 3.

N. Vibration Isolation of Ductwork:

1. All discharge runs for a distance of 50' from the connected equipment shall be isolated from the building structure by means of Specification 10 hangers or Specification 5 floor isolators. Spring deflection shall be a minimum of 0.75 in.

2. All duct runs having air velocity of 1000 fpm or more shall be isolated from the building structure by Specification 11 hangers or 5 floor supports. Spring deflection shall be a minimum of 0.75 in.

O. Seismic Restraint of Ductwork:

1. Seismically restrain all duct work with Specification 12 or 13 restraints as listed below:

   a. Restrain rectangular ducts with cross sectional area of 6 sq. ft. or larger.

   b. Restrain round ducts with diameters of 28 in. or larger.

   c. Restrain flat oval ducts the same as rectangular ducts of the same nominal size.

2. Transverse restraints shall occur at 30' intervals or at both ends of the duct run if less than the specified interval. Transverse restraints shall be installed at each duct turn and at each end of a duct run.

3. Longitudinal restraints shall occur at 60' intervals with at least one restraint per duct run. Transverse restraints for one duct section may also act as a longitudinal restraint for a duct section connected perpendicular to it if the restraints are installed within 4' of the intersection of the ducts and if the restraints are sized for the larger duct. Duct joints shall conform to SMACNA duct construction standards.

4. The ductwork must be reinforced at the restraint locations. Reinforcement shall consist of an additional angle on top of the ductwork that is attached to the support hanger rods. Ductwork is to be attached to both upper angle and lower trapeze.

5. A group of ducts may be combined in a larger frame so that the combined weights and dimensions of the ducts are less than or equal to the maximum weight and dimensions of the duct for which bracing details are selected.

6. Walls, including gypsum board non bearing partitions, which have ducts running through them may replace a typical transverse brace. Provide channel framing around ducts and solid blocking between the duct and frame.

P. All mechanical equipment shall be vibration isolated and seismically restrained as per the schedules in paragraph S of this Specification.

Q. Seismic Restraint Exclusions:

1. Piping:

a. All piping less than 2-1/2 in. in diameter except those listed below.

b. All gas piping less than 1 in. I.D.

c. All piping in boiler and mechanical equipment rooms less than 1-1/4 in. I.D.

d. All clevis or trapeze supported piping suspended from hanger rods where the point of attachment is less than the 12 in. in length from the structure to the structural connection of the clevis or trapeze.

e. All PVC and fiberglass suspended waste or vent pipe 6 in. in diameter and smaller.

2. Ductwork:

a. Rectangular, square or oval ducts less than 6 sq. ft. in cross sectional area.

b. Round duct less than 28 in. in diameter.

c. Duct supported by hanger rods where the point of attachment is less than 12 in. in length from the structure to the structural connection of the duct work.

R. Suspended Equipment: VAV boxes and fan powered equipment weighing less than 50 lbs. and rigidly connected to the supply side of the duct system and supported with a minimum of 4 hanger rods.

S. Schedules:

1. Equipment Isolator and Seismic Restraint Schedule:

	Vibration Isolation and or Seismic Restraint

Equipment Schedule	Specification	Static Deflection
Air Handling Unit	1,4,19	Internal1 1-½" Isol.
Fan Coil Unit	4 & 18	
VAV Boxes	10, 12, 19	.75 in.
In-Line Fans	10, 12, 19	.75 in.
Unit Heaters	10, 12, 19	.75 in.
Cabinet Heaters	4 & 18	
Pumps	1, 4, 18, 23	
Boiler	4 & 19	
Condensing Unit & Chiller	-	-
Suspending Fan Coil	10 & 12	

2.28 CUSTOM ROOFTOP COOLING/HEATING DOAS UNITS

PART 1 – GENERAL: CUSTOM ROOFTOP DOAS UNITS

A. SECTION INCLUDES
1. Design, performance criteria, controls, and installation requirements for indoor mounted Custom Air Handling Units.

B. REFERENCES
1. AFBMA 9 – Load Ratings and Fatigue Life for Ball Bearings
2. AMCA Publication 99 – Standards Handbook
3. AMCA Standard 203 – Field Performance Measurement of Fan Systems
4. AMCA Standard 210 – Laboratory Methods of Testing Fans for Performance Rating
5. AMCA Standard 300 – Reverberant Room Method for Sound Testing of Fans
6. AMCA Standard 500 – Laboratory Methods for Testing of Dampers and Louvers
7. ARI Standard 410 – Forced Circulation Air-Cooling and Air-Heating Coils
8. ANSI/ASHRAE Standard 111 – Practices for Measurement, Testing, Adjusting and Balancing of Building HVAC Systems
9. ASHRAE Standard 52.1 – Dust-Spot Procedures for Testing Air-Cleaning Devices
10. ANSI/ASHRAE Standard 52.2 – Method of Testing Air-Cleaning Devices for Removal Efficiency by Particle Size
11. ANSI/ASHRAE 15 – Safety Standard for Refrigeration Systems
12. ANSI/ASHRAE 62.1 – Ventilation for Acceptable Indoor Air Quality
13. ANSI/ASHRAE 90.1 – Energy Standard for Buildings Except Low-Rise Residential

14. IECC 2018 – International Energy Conservation Code with Massachusetts Amendments.
15. ARI 1060 – Performance Rating of Air to Air Energy Recovery Ventilation Equipment
16. ASTM A-653 – Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dipped Process
17. ASTM B117 – Standard Practice for Operating Salt Spray Apparatus
18. IBC 2006-2012 – International Building Code
19. NEMA MG1 – Motors and Generators
20. NFPA 70 – National Electric Code
21. NFPA 90A – Standard for the Installation of Air Conditioning and Ventilating Systems
22. UL 900 – Test Performance of Air Filters
23. UL 1995 – Standard for Heating and Cooling Equipment

C. SUBMITTALS

1. Submit shop drawings and product data in accordance with Division 1
2. Submittals shall include the following:
   a. Dimensioned plan and elevation view drawings, including motor starter and control cabinets, required clearances, and location of all field connections.
   b. Cabinet material, metal thickness, finishes, insulation and accessories.
   c. Ladder-type schematic drawing of the power and auxiliary utility field hookup requirements, indicating all items that are furnished by the manufacturer.
   d. Manufacturer's performance of each unit. Selection shall indicate, as a minimum, the following:
      i. Fan curves with system operating conditions indicated.
      ii. Certified coil performance ratings with system operating conditions.
      iii. Calculations required for base rail heights to satisfy condensate trapping requirements of cooling coil.
      iv. Filters with performance characteristics.
      v. Rated load amp draw.
      vi. Approximate unit shipping weight.

D. OPERATION AND MAINTENANCE DATA

1. Include data on design, inspection and procedures related to preventative maintenance. Operation and maintenance manuals shall be submitted at the time of unit shipment.

E. QUALIFICATIONS

1. Manufacturer shall be a company specializing in the design and manufacture of custom air handling equipment and in business for no less than 15 years.
2. Each unit shall bear an ETL label, conforming to UL Standard 1995.
3. Units shall comply with the requirements of UL 1995 and NFPA 90.
4. Wind Restraint Performance:

a. Each unit shall have a prominently displayed IBC 2006-2012 (or more current) Seismic Compliance Label issued by an independent third party approval agency which is specific for the size of the component and tested acceleration levels.

F. DELIVERY, STORAGE, AND HANDLING

1. Deliver, store, protect and handle products to site under the supervision of the owner in accordance with the manufacturers Operation and Maintenance Instructions.

G. SEQUENCING AND SCHEDULING

1. Coordinate work performed under this section with work performed under the separate installation contract.

H. WARRANTY

1. The complete unit shall be covered by a part only warranty issued by the manufacturer covering the first year of operation. The warranty period shall start on the date of equipment startup or six months after the date of shipment from factory, whichever occurs first. Contractor shall insure units are shipped so as to be fully installed and started prior to the 6 month warranty from shipping period expires.
2. The installing contractor shall provide labor warranty during the unit's first year of operation.
3. Refer to 3 year parts, labor and maintenance warranty requirement for this equipment elsewhere in the spec.

PART 2 – PRODUCTS: CUSTOM ROOFTOP DOAS UNITS

A. MANUFACTURER

1. Basis of design is Hakon. Approved equal manufacturers shall be CAHS or Energylabs Inc. and shall meet or exceed performance and construction aspects as described and detailed herein. Requests for prior approval must be submitted 10 days prior to bid date. Submittal is to be in sufficient detail to determine equivalency. Substitution requests must originate from a bidder which is a general contractor or mechanical contractor plan record holder.

2. Besides needing to meet all the performance requirements and characteristics specified herein and on the drawings, the specified product as well as any approved equal must be constructed to fit on the existing steel support frames, have supply and return connection that do not impact existing steel framing and cross bracing and must not exceed the weights of the specified units. The units dimensional length (no width) may be allowed to exceed the existing steel frame by no more than 12" in the long dimension and if so the unit base rail must be capable of supporting the overhang of said unit without any added steel framing below.

B. GENERAL

1. Units shall be completely factory assembled and tested with the exception of unit splits as required for shipping or installation requirements as indicated on the

schedule and drawings. The equipment's cooling, heating, humidifying, ventilating, exhausting capacity and performance shall meet or exceed that shown on the schedule. Tags and decals to aid in service or to indicate caution areas shall be provided. Electrical wiring diagrams shall be attached to the control panel access doors. Operation and Maintenance manuals shall be furnished with each unit.

2. IBC Seismic Compliance
    2. Complete unit shall be independently certified to meet the seismic compliance standards of the International Building Code, IBC-2000, 2003, 2006, 2009, 2012, 2015
3. Hurricane Resistant Construction
    1. Units shall comply with the High Velocity Hurricane Zone requirements of the Florida Building Code and approved to bear a label stating “Miami-Dade County Product Control Approved.” A copy of the Miami-Dade County Notice of Approval (NOA) shall be provided to the user upon request.
        a. NOA shall include a Large and Small Missile Impact rating.
        b. NOA shall include a “Maximum Design Pressure Positive” rating of 110.
        c. NOA shall include a “Maximum Design Pressure Negative” rating of 110.
4. Snow Load
    1. Must be capable of roof snow load of 60 lbs / sq ft.
5. Efficiency
    1. Unit part load and full load EER ratings must meet or exceed those specified in IECC 2018.

C. CABINET CONSTRUCTION

1. Cabinets shall be constructed in a watertight and airtight manner. The manufacturer's standard cabinet construction shall result in an ASHRAE/ANSI Standard 111 Leakage Class 5 rating, or better, as measured in accordance with AMCA Standard 210. A leakage rate as a percent of airflow shall only be submitted following calculation at specific project conditions. Maximum casing leakage (cfm/100 ft^2 of casing surface area) = CL X $P^{0.65.}$ Published leakage rates at generic conditions shall not be submitted.
2. Casing deflection shall not exceed L/200 at +12.0 w.g. in all positive pressure sections and -12.0 w.g. in all negative pressure sections where L is defined as the panel span. Panels shall be designed to deflect no more than 1/200 (.0005” per inch) of span under operating design conditions when measured at the panel span. Casing shall be rated for 1% leakage at 1.5 times the operating pressure with a maximum overall pressure of 12” wc.
3. The unit shall be constructed on a 5” ¼” thick HSS structural steel, welded tubular steel base. Base tubing shall be cold-formed carbon steel, electric resistance welded. Equipment using a die-formed sheet metal base is not acceptable. Formed intermediate cross members shall be constructed of hot rolled 12-gauge galvanized steel. After fabrication, the base frame shall be thoroughly cleaned and coated with high solids, polyamide epoxy paint system for off shore marine standard and enamel painted. Formed steel and bolted bases are NOT acceptable.
4. Units shipped in multiple sections shall be engineered for ease of field assembly. Gasket supplied with the unit shall be a high-quality weather resistant closed-cell EPDM sponge rubber. Each section shall include a permanent label to aid in proper field assembly. All gasket and necessary assembly hardware shall ship loose

with unit. Floors shall be designed to deflect no more than 1/200 of span under operating conditions.

5. Floors
    a. Shall be fabricated of 3/16” aluminum tread plate All floor sheets shall be isolated from the base assembly with an EPDM thermal break gasket.
    b. Floors shall be insulated with a two-part polyurethane water impervious foam insulation.
    c. Under liner shall be fabricated of 16-gauge G-90 galvanized steel
    d. Panels shall be 2” thick double wall construction. Panel joints shall be sealed with an industrial EPDM gasket to form a water and airtight seal. Air handling manufacturers using caulk to seal panels must include an owner witnessed field leakage test. The test shall require the unit to be field design air flow tested and cabinet leak tested for 1% at 1.5 times the operating pressure.
    e. Panels shall be individually removable for service without removing the roof or compromising the integrity of the cabinet wall. Panels shall be joined with 5/16” bolts that can be removed and refastened. Panel attachment with screws is not acceptable. All panels shall utilize thermal break construction between the exterior panel and the interior liner and between the panels and the base and roof frames
6. To allow for added protection from ruptured coils or piping, floors in specified section(s) shall include a drain outlet routed through the perimeter base.
7. Wall and roof panels
    a. Panels shall be 2” thick double wall construction. Panel joints shall be sealed with an industrial EPDM gasket to form a water and airtight seal. Air handling manufacturers using caulk to seal panels must include an owner witnessed field leakage test. The test shall require the unit to be field design air flow tested and cabinet leak tested for 1% at 1.5 times the operating pressure.
    b. Panels shall be individually removable for service without removing the roof or compromising the integrity of the cabinet wall. Panels shall be joined with 5/16” bolts that can be removed and refastened. Panel attachment with screws is not acceptable. All panels shall utilize thermal break construction between the exterior panel and the interior liner and between the panels and the base and roof frames.
    c. For long term durability, exterior panels shall be a minimum 16-gauge stucco embossed high strength aluminum.
    d. Interior liners shall be a minimum 16-gauge aluminum. Panel liners shall be of a single piece construction and attached to the exterior panels with a full thermal break. To allow for cleaning, no fasteners shall be used on the exposed liner surface. Single wall units are not acceptable.
8. Insulation
    a. All wall and roof panels shall be insulated with an injected foam insulation with an R value of 13.2 / inch. Panels shall be designed to deflect no more than 1/200 of span under operating design conditions when measured at the panel seam. Insulation shall fill the panel without voids. Panels shall have a minimum.
9. Access doors shall be provided into all sections of the air-handling unit as indicated in the plan documents. Doors shall be sized as shown on plan drawings, shall be a minimum 2” thick with R13 polyurethane foam insulation and shall be double wall construction using the same material type as the corresponding section. Doors shall comply with the requirements of UL 1995 and NFPA 90. The door frame shall be

0.125” extruded 6063-T5 aluminum. Each door shall be mounted with adjustable die cast aluminum hinges. All doors and mounting frames shall incorporate a thermal break design and the doors shall seal to a replaceable extruded EPDM sponge rubber gasket. Doors shall open against static pressure or shall include a pressure relief feature on the door latch.

a. The door latch assembly shall consist of a roller cam compression arm with a chrome plated steel inner handle and glass fiber / nylon composite outer handle. One tool operated lock shall be provided on each fan section access door. All doors shall have a minimum of two latches. Doors over 72” tall shall have 3 or more latches.

b. A 10”x12” thermal pane viewing window with one wire mesh safety glass pane and one clear pane shall be provided. The frame shall have a no-through-metal thermal break design. Viewing windows shall be on all doors serving a lighted section. Windows on doors exposed to unit mounted UVC light shall use glass that is resistant to UVC transmission.

10. The entire unit shall be painted with a baked epoxy finish with custom color selection by the Architect.

11. The entire unit, including walls, roof, doors, joints, and seams shall include thermal break construction. This construction shall be supported by tested performance producing no condensation on the exterior surface when the air tunnel temperature is 50°F DB under the following exterior conditions:

$$(Th - 50) / (Th - Tdp) < 3.4$$

a. Th = Ambient dry bulb temperature (°F) external to housing

b. Tdp = Ambient dew point temperature (°F) external to housing

D. FAN ASSEMBLIES – DIRECT DRIVE FAN ARRAY

1. Fan Arrays shall be direct-drive, non-overloading SWSI plenum fans designed for industrial duty and suitable for continuous operation.

i) Fans shall be arranged in an array using one or more welded structural steel assemblies and shall be of the size and quantity specified in the unit schedule. Screwed or riveted frames are unacceptable. Fan assemblies shall be attached directly to base structural members.

ii) Fan wheels shall have a minimum of 12 airfoil blades for superior sound characteristics and shall be constructed of aluminum to reduce rotational weight and vibration. Fan blades shall be extruded aluminum for uniformity and improved vibration characteristics.

iii) Each fan and motor assembly shall be independently isolated within the structural assembly using 1 inch deflection spring isolators. Isolators shall be mounted in a three-point arrangement that provides both vertical and horizontal (thrust) isolation and shall not require field adjustment. If hard mounted or rubber in shear is used in place of internal spring isolations, external isolation of the entire unit is required. Isolation system shall be seismic rated to withstand seismic forces in excess of 4G horizontally and vertically to satisfy specified IBC seismic requirements.

iv) A fan inertia base shall be provided or the fan structure shall exceed an equivalence of 2x mass of the total rotating parts of the fan array. Fan and motor assemblies shall be designed such that no natural frequencies exist within the operating RPM range of the fan, eliminating the need for “lockout” frequency settings in the variable speed drive. The purchasing contractor will

be responsible for all costs associated with externally isolating any unit that does not include individual fan isolation.

v) All fan arrays shall meet the minimum motor efficiency, maximum brake horsepower and total motor horsepower values scheduled. All fans shall be selected to operate at a point no higher than 90% of the peak static pressure rating as defined by the fan performance curve at the selected operating speed. Manufacturer must ensure maximum fan RPM is below the first critical speed. Fans shall be Class 2 construction.

vi) All fan and motor assemblies shall be dynamically balanced by the manufacturer to a maximum allowable vibration of 0.040 inches per second at design RPM and a maximum 0.080 inches per second overall vibration limit to bring the fan balance in conformance to a BV-5 Grade G1 per ANSI/AMCA 204. In addition, the manufacturer shall insure that no critical frequencies exist in the fan operating range by varying motor speed in 1Hz increments from design RPM to 50% of design RPM.

2. Unloading

i) Fans shall be provided with unloading technology to allow fan modulation without surge from 100% to 10%; while maintaining the part load static pressure requirements of the system. There shall be no static pressure or intake plenum losses or any horsepower penalty associated with the system.

ii) BalanceStream is a self-contained system independent of the building system temperature controls. No powered actuators or control signals are required. Any control points required to operate the unloading sequence shall be wired by the AHU manufacturer to a single point of control for the building automation system to interface. If control points are required, coordination with the BASD manufacturer on control sequence responsibilities shall be required at time of submittal approval.

iii) They system shall provide a positive shutoff for each fan in case of a fan failure. Each fan shall be provided with an isolation or backdraft damper to prevent bypass in the event of a motor failure. Blank off plates requiring manual installation are not acceptable.

iv) Fan cycling to allow stable part load operation shall be allowed only if a maximum of 50% of the fans will be cycled off at any time. Each fan is to be cycled in such a manner that all fans operate an equal number of hours in any given 168 hour (1-week) operating period. Control system shall indicate the individual fans operating and not operating. A separate control signal shall be required to indicate fan failure, separate from an indication that a fan is intentionally controlled to be off.

v) Fan curves shall be submitted; with the system curve indicating the minimum system operating static pressure and the point of fan surge.

3. Motors

i) Electrical characteristics and horsepower shall be as specified on the project schedule.

ii) Motors shall be Premium Efficiency per NEMA MG1 Table 12-12 ODP type, shall have NEMA Class F insulation, shall meet NEMA Standard MD-1 Inverter Duty rating and shall be designed to withstand 1600V peak voltage spikes and rise times ≥0.1 microseconds.

iii) Motors shall have grease lubricated ball bearings designed to deliver a minimum L10 life of 250,000 hours at full load and the maximum operating RPM of the associated fan. Grease zerks and spring loaded grease relief

valves shall be provided in each motor to allow easy bearing lubrication without damaging the seals due to over lubrication.

iv) For efficient operation in a direct drive application, motors shall be capable of operating greater than 60HZ to at least the design operating speed of the fan.

v) Motors shall be factory wired to a motor control center for connection to a disconnect switch or VFD. The motor control center shall include for each motor circuit a control device providing overload protection, short circuit protection and a manual disconnect means, and all circuits shall be wired to a common main panel terminal block. Each motor shall be factory wired directly to an individual VFD. All motors shall operate at all times and be controlled in unison, maintaining a consistent and uniform airflow pattern over coils, filters and other devices.

vi) Each motor shall be provided with a shaft grounding device to harmlessly bleed potential induced shaft voltages to ground.

vii) All motors shall be dual nameplated for overspeed purposes in a 4 fan direct drive application.

4. Warranty

i) All fan/motors rotating parts shall be warranted by the unit manufacturer for a full five (5) years from date of unit start-up. Parts warranties provided by third parties are not acceptable.

5. Options

i) In the fan section, provide an overhead motor removal system to facilitate motor replacement.

(1) The assembly shall be either a manually operated winch, capable of being easily moved to any motor location or provide a structural steel I beam for mounting a trolley to assist in fan motor removal. Trolley assembly shall be provided by AHU manufacturer. The beam system shall be mounted overhead of the fan and motor. The beam system shall be supported and mounted to the unit's base support system.

ii) Fans shall be provided with inlet and outlet guards to protect service personnel.

iii) Each array shall be provided with one inlet airflow blank-off plate to be used in case of a motor failure. Plate to include handles and latches for quick installation.

E. FAN ARRAY CONTROLS

1. Fan arrays shall be controlled using a common control signal as provided by the building ATC (such as the duct static control signal), to modulate the fan speed.
2. All fan array controls for unloading and air flow measuring shall be provided by the AHU manufacturer, not by the ATC however, ATC shall command the fans on and off, send them static pressure or airflow volume or fan speed reset commands. The ATC shall monitor all fan airflows, speeds, current, status, etc… thru the factory fan array controller.
3. Each fan array in the air handling unit shall be provided with a factory installed airflow measuring instrument. Every fan in the array will have an airflow measuring device that is guaranteed by the unit manufacturer to have no impact on the fan airflow performance and will not increase the fan sound power. The output of the airflow measurement device on each fan shall be wired by the unit manufacturer back to a central processor mounted on the cabinet exterior that will add the flow from each fan to provide a total airflow for the fan array. Using one air flow

measuring device and multiplying by the number of fans provided is not acceptable due to lack of accuracy. The central processor shall be able to detect and report a fan failure. Auxiliary contacts on the motors starters are not acceptable as fans can fail without tripping overloads. Current sensors wired into the central processors can be utilized.

4. Piezometric volume taps with pressure transducers are acceptable. Transducer accuracy shall be 1% of pressure reading from full scale down to 10% of full scale reading to improve accuracy to less than 0.5% of calculated flow from 100%-30% of flow. The square root linearization and conversion of the pressure signal to flow shall be done at the central processor.
5. The factory fan array control system shall be fully compatible with the Building Automation System via native BACnet, Modbus and N2 communication. Coordinate interface protocol with campus control vendor ESC however, as a minimum, BacNet interface shall be considered basis of design.

F. FAN SPEED CONTROL

1. Each variable air volume supply and return fan shall be provided with an individual variable frequency drive. Drives shall be factory mounted and wired to the motor with adequate ventilation provided. The VFD shall be self-contained, totally enclosed in a NEMA 1 ventilated cabinet and capable of operation between 0 and 40-degree C. The VFD shall be 95% efficient at 100% rated output power, 60 Hz. The VFD shall be UL listed.

   Drives shall be mounted on the exterior of the unit in a NEMA-4 electrical control enclosure {that is shipped loose for field mounting by others}.

   Fans shall modulate to a (CFM) without surge. De-energizing fans shall not be an accepted format. AHU manufacturer must submit proper fan curves demonstrating unloading without fan surge.

2. The factory fan array control system shall be fully compatible with the Building Automation System via native BACnet, Modbus and N2 communication. Coordinate interface protocol with campus control vendor ESC however, as a minimum, BacNet interface shall be considered basis of design

G. UNIT SOUND POWER

1. Fan sound power levels (dB) for the unit shall not exceed values as specified on the equipment schedule.
2. Unit manufacturer shall provide certified inlet, supply and casing radiated, sound power levels based on the final unit configuration.

H. COILS

1. Provide complete coil section(s) with service access door(s) as shown on the plan drawings. Coil connections shall extend through the section casing for ease of installation. Coil connections must be sealed from both the inside and exterior surfaces of the panel with the sleeve of the inner seal covering the pipe within the depth of the panel, all to minimize leakage and condensation. An integral stainless steel air seal which completely seals around the coil casing and extends to the unit pressure bearing surface shall be provided. Air seals / safing materials that are mechanically fastened to the inner liner of the cabinet only shall be constructed of

16 gage materials to match the material type in the appropriate section and shall be gasketed and have fasteners every 3 inches.

2. Multiple, “stacked” coil arrangements must be constructed so as to allow independent removal of any coil without the removal of another within the coil bank.
3. All coils shall meet or exceed the capacities specified on the mechanical schedule and all water coil performances shall be certified in accordance with the AHRI Forced Circulation Air Heating and Air Cooling Coil certification program which is based on AHRI Standard 410. Face velocities shall not exceed those specified on the mechanical schedule.
4. All cooling coil sections shall include a double sloped drain pan constructed from 304L stainless steel. All corners shall be welded watertight. Coils shall rest on stainless steel supports. The pan shall have a minimum pitch of 2" from high point to the bottom of the drain outlet connection, providing at least a 1/8” per foot slope. The drain pan shall be insulated with a 2-part sprayed on polyurethane, water impervious foam. Insulation shall be applied to the entire under side of the drain pan and coil section base assembly. If multiple stacked coils are used, intermediate drain pans are required. Intermediate pans shall be insulated and drained with 3/4” copper down-comers to the main pan.
5. Hot Water coils shall be of a staggered tube design with high efficiency die formed corrugated plate-type fins for maximum performance. All coils shall be tested with 400 psig compressed air under clear water. Coils shall be designed to operate at 300 psig internal pressure and up to 250ºF. Tubes shall be 5/8" diameter, seamless 0.020" wall copper, mechanically expanded into full drawn fin collars for a continuous compression bond over the full finned length for high efficiency performance. Coil casings shall be a minimum 16-gauge stainless steel. Coil casing reinforcements shall be required for fin lengths over 42". Coil fins shall be 0.0075" thick aluminum. Coils shall be serviceable using 0.25" M.P.T. drain and vent taps on the supply and return headers. Threaded seamless red brass coil connections shall be brazed to copper supply and return headers.
6. Refrigerant coils shall be of a staggered tube design with high efficiency die formed corrugated plate-type fins for maximum performance. All coils shall be tested with 350 psig compressed air under clear water. Coils shall be designed to operate at 250 psig internal pressure. Tubes shall be 5/8" diameter, seamless 0.020" wall copper, mechanically expanded into full drawn fin collars for a continuous compression bond over the full finned length for high efficiency performance. Coil casings shall be a minimum 16-gauge stainless steel. Coil casing reinforcements shall be required for fin lengths over 42". Coil fins shall be 0.0075" thick aluminum. Each coil circuit shall be furnished with a red brass distributor with solder type connections and a copper sweat suction connection. A minimum of two stacked DX cooling and reheat coils with row split circuits shall be provided and sized to insure stable DX cooling and reheat operation down to 10% of the rated supply airflow. Manufacturer shall size the DX coils in varying capacities to match the condenser section and achieve performance at low airflow, for example one DX coil at 1/3 capacity and other DX coil at 2/3 capacity or other variation as predicated by the manufacturer to insure adequate airflow velocity across operating coil at minimum 10% unitary airflow realizing that the inactive idle coil shall be dampered off at low airflows as specified in the sequence of operation. Hot gas reheat coils shall be sized to reheat air off the DX cooling coils from design leaving air temperature of no higher than 52°F to a minimum of 70°F at all operating airflows.

I. WRAP-AROUND HEAT PIPE SECTIONS

1. Air Handlers shall be equipped with Standard Tilted Enhanced Dehumidifier Heat Pipes supplied by Heat Pipe Technology, Inc. to precool the return/outside air and reheat the supply air in a wrap-around configuration. The precool Heat Pipe module shall be located immediately before the cooling coil and the reheat module of the Heat Pipe shall be located immediately after the cooling coil. Heat Pipe circuits comprise multiple tubes connected in series, end-to-end to form a closed, continuous loop. Both vapor and liquid will travel in the same direction around the circuit in a single convectional path, making wicking and capillary action unnecessary for continuous heat transfer. Both Heat Pipe modules shall be inside the equipment cabinet. The interconnecting piping between the Heat Pipe modules shall be located within the assembled access/coil/access sections. If not, the piping shall be external, but enclosed within a removable, insulated enclosure supplied and installed by others. When possible, all interconnecting piping shall be located at the end of the cooling coil opposite from the coil header and piping connections. Any deviation from the specifications must be approved by the engineer no less than ten days prior to the project bid date. No consideration of alternates will be given after that time. Heat pipes shall be completely manufactured and fully assembled at the manufacturer's facility or on site by factory personnel. Conversion of third-party coils is not acceptable.

2. The precool Heat Pipe module shall be located immediately upstream of the cooling coil section and the reheat Heat Pipe module shall be located immediately downstream of the cooling coil section with drain pans, or a single extended drain pan, positioned beneath. θ For optimal accessibility between the cooling coil and the Heat Pipe modules, the air handler cooling coil section(s) shall be supplied with two (2) factory installed blank sections located immediately before and after the cooling coil section. Each section shall be provided with an integral condensate drain pan and drain pan condensate connection of the same construction as specified for the cooling coil. The precool Heat Pipe module shall be located within the provided blank section before the cooling coil section, and the reheat Heat Pipe module shall be located within the provided blank section after the cooling coil section.

3. All or a portion of the Dehumidifier Heat Pipe circuits shall be equipped with solenoid operated control valves to control the operation of the Heat Pipe circuits. The electrical power required by the solenoid valves shall be: θ 24 VAC θ 120 VAC. The solenoid valves shall be wired to a terminal block within a NEMA enclosure located on the: θ exterior surface of the equipment cabinet or θ interior as indicated.

4. The Building Automation System shall provide the sensors necessary for determination of heat pipe staged operation and the BAS computer shall be programmed to send the operating control signals to the solenoid valves as required for correct system operation. The control signal shall go through a BAS interface installed near the heat pipe NEMA box. All additional wiring, relays, transformers, power supply etc. necessary to interface with the equipment control system, shall be provided and installed by others. Closing of a valve shall inactivate the Heat Pipe circuit in which it is installed. The valves shall be normally open. The control valves shall be grouped such that each group of valves shall control a designated fraction of the Heat Pipe circuits. With all control valves open, the Dehumidifier Heat Pipe assembly will operate at full capacity. If all the circuits are equipped with control valves, then closing all the valves will stop all Heat Pipe operation. Manufacturer shall provide at least three (3) references for successful controllable wraparound heat pipe installations in operation for at least three (3) years.

5. The Heat Pipe supplier shall have a minimum of 5 years of experience designing and installing Heat Pipes specifically for dehumidification applications.

6. The tubes shall be 1/2" OD copper, of specific design for Heat Pipe application, permanently expanded onto the fin collar to form a firm, rigid, and complete pressure contact at all operating conditions. Aluminum tubes will not be allowed.

7. The fin surface shall be continuous plate type θ aluminum θ copper fins of specific design to produce maximum heat transfer efficiency for Heat Pipe applications. Airside pressure loss shall be as given on the schedule, or otherwise specified. Fin density and the number of rows of tubes shall be as specified.

8. The Heat Pipe modules shall have an optional protective coating of E-Coat, similar to Electrofin or phenolic, similar to Heresite. Heat pipes shall be dipped and completely submerged to insure full coverage of coating - spray coatings are not acceptable.

9. Heat transfer fluid shall be classified as Safety Group A1 in ASHRAE Standard 34-2013.

10. Heat Pipe capacities, entering and leaving dry and wet bulb temperatures, and face velocity shall be as specified.

11. The Heat Pipes shall be installed as shown on the submittal drawings.

12. Frames, mounting structure, and drain pan extensions (if required) shall be minimum 16 gauge θ galvanized steel θ stainless steel.

13. Heat Pipe interconnecting piping and circuitry shall be as specified by Heat Pipe Technology design. Each circuit shall be individually processed, charged, hermetically sealed, and tested.

14. Scheduled effectiveness or heat recovery shall be met at a minimum and total pressure drop shall not be exceeded. The resulting Recovery Efficiency Ratio, or RER, shall therefore be met at a minimum.

15. The Heat Pipes shall be ETL listed to UL standard 207 and CSA C22.2.140.3.

16. The Heat Pipe heat exchanger shall have a five (5) year limited warranty. All components such as valves and dampers shall carry a 12 month warranty.

J. FILTERS

1. Provide complete filter section(s) with filter racks and service access door(s) as shown on the plan drawings. Holding frames provided for medium efficiency applications will be either upstream or downstream accessible. Holding frames provided for high efficiency applications will be upstream accessible, only. Holding frames shall be constructed from heavy gauge galvanized steel and shall be equipped with polyurethane foam gaskets. Frames shall be installed with vertical stiffeners and appropriate frame-to-frame sealant to provide a rigid leak tight assembly. An integral air seal which completely seals around the filter frame assembly and extends to the unit pressure bearing surface shall be provided. Air seals / safing materials that are mechanically fastened to the inner liner of the cabinet only shall be constructed of 16 gage materials to match the material type in the appropriate section and shall be gasketed and have fasteners every 3 inches

Filter fasteners shall be capable of being installed without the requirement of tools, nuts or bolts. The holding frame shall be designed to accommodate standard size filters with the application of the appropriate type fastener. The filter rack shall be designed to use standard 24”x24” and 12”x24” filters only. Odd sized filters are not allowed. Holding frame assemblies shall be sized to meet or exceed the face area specified by the mechanical schedule.

2. Gauges
   a. A Magnehelic differential pressure gauge shall be provided factory installed for measuring the pressure drop across the filter bank-single stage. The gauge shall be a diaphragm-actuated dial type, 4¾" O.D., with white dial, black figures and graduations and pointer zero adjustment.
3. MERV 8 filters shall be provided on the main return air stream (upstream of energy wheel exhaust, in the outdoor airstream upstream of the energy wheel intake. High efficiency MERV 13 rigid mini-pleat filters shall be provide upstream of the unit coils and shall be 4” deep, totally rigid and disposable type. Each filter shall consist of water-laid micro fine fiberglass media formed with closely spaced pleats. The enclosing frame shall be double walled water resistant beverage board. The filter media shall have an average efficiency of 95% as rated by ASHRAE Standard 52.1 test methods. Provide filters for start-up and flush out and post flushout.

K. ENERGY RECOVERY SEGMENT

1. Unit shall contain a factory mounted and tested energy recovery wheel(s). The energy recovery wheel(s) shall be mounted in a rigid frame containing the wheel drive motor, drive belt, wheel seals and bearings. Frame shall slide out for service and removal from the cabinet.

2. The energy recovery component shall incorporate a rotary wheel in an insulated cassette frame complete with seals, ECM drive motor and drive belt.

3. Wheels shall be wound continuously with one flat and one structured layer in an ideal parallel plate geometry providing laminar flow and minimum pressure drop-to-efficiency ratios. The layers shall be effectively captured in stainless steel wheel frames or aluminum and stainless steel segment frames that provide a rigid and self-supporting matrix.

4. Wheels shall be provided with removable energy transfer matrix. Wheel frame construction shall be a welded hub, spoke and rim assembly of stainless, plated and/or coated steel and shall be self-supporting without matrix segments in place. Segments shall be removable without the use of tools to facilitate maintenance and cleaning. Wheel bearings shall be selected to provide an L-10 life in excess of 400,000 hours. Rim shall be continuous rolled stainless steel and the wheel shall be connected to the shaft by means of taper locks.

5. All diameter and perimeter seals shall be provided as part of the cassette assembly and shall be factory set. Drive belts of stretch urethane shall be provided for wheel rim drive without the need for external tensioners or adjustment.

6. The energy recovery cassette shall be an Underwriters Laboratories Recognized Component for electrical and fire safety. The wheel drive motor shall be an

Underwriters Laboratory Recognized Component and shall be mounted in the cassette frame and supplied with a service connector or junction box. Thermal performance shall be certified by the manufacturer in accordance with ASHRAE Standard 84, Method of Testing Air-to-Air Heat Exchangers and AHRI Standard 1060, Rating Air-to-Air Energy Recovery Ventilation Equipment. Cassettes shall be listed in the ARI Certified Product. Wheel effectiveness must meet the conditions specified in the schedules but in no case shall sensible effectiveness and total energy effectiveness be less than 70%.

7. Energy recovery wheel cassette shall carry a 5 year non-prorated warranty.

8. Unit shall include 2” MERV 8 pre-filters and 4 inch thick, pleated panel outside air filters with an ASHRAE efficiency of MERV rating of 13, upstream of the wheels. Unit shall include 2 inch thick, pleated panel exhaust air filters with an ASHRAE efficiency of 30% and MERV rating of 8, upstream of the wheels. Provide 4 spare sets in addition to those required during building flush-out period.

9. Hinged service access door shall allow access to the wheel(s).

10. Total energy recovery wheels shall be coated with silica gel desiccant permanently bonded by a process without the use of binders or adhesives, which may degrade desiccant performance. The substrate shall be lightweight polymer and shall not degrade nor require additional coatings for application in marine or coastal environments. Coated segments shall be washable with detergent or alkaline coil cleaner and water. Desiccant shall not dissolve nor deliquesce in the presence of water or high humidity.

11. Unit shall include a variable speed wheel to support both economizer and energy recovery wheel defrost control which includes an adjustable temperature sensor and wheel pressured sensor which, when frost is detected, slows allowing warm exhaust air to defrost the wheel. Wheel bypass dampers shall also be provided to support economizer cooling once the wheel has fully stopped.

12. Unit shall include energy recovery wheel rotation detection sensors and a set of normally open and normally closed contracts for field indication of wheel rotation.

13. Section shall include night bypass recirculation damper as well as wheel OA and EA bypass dampers.

L. DAMPERS

A. Mixing box and economizer outdoor air return air and exhaust air openings shall be airfoil low-leak dampers, Damper shall be {opposed} {parallel} blade type. The frame shall be fabricated from 16-gauge galvanized steel. Damper shall meet the leakage requirements of ASHRAE Std. 90.1 and of the International Energy Conservation Code by leaking less than 3 CFM/sq. ft. at 1” of static pressure, and shall be AMCA licensed as a Class 1A damper.

M. ELECTRICAL POWER AND CONTROLS

1. Unit operating voltage shall be 460V, 3 phase, 60Hz. All wiring and electrical equipment supplied by the manufacturer shall conform to and be installed in accordance with the requirements of UL1995.

   Provide copper wires, bus bars, and fittings throughout, except internal wire of the control transformer may be aluminum if copper termination is provided. Identify power supply terminals with permanent markers. The maximum temperature of terminals shall not exceed 167°F (75°C) when the equipment is tested in accordance with its rating. Wiring shall be run in plated flexible metal conduit.

   Mount a permanent nameplate on the unit to display the manufacturer, serial number and model number, date of manufacture, horsepower, current rating and voltage.

2. Furnish and install a non-fused disconnect switch for the supply & return fans and condenser sections. Units shall be internally wired in the field to terminate to a single point power connection with disconnect switche(s) mounted on the exterior of the unit in a housed ventilated panel.
3. Each section provided with a service access door, or as indicated on the plan drawings, shall be equipped with a vapor proof LED service light. All lights shall be completely installed and wired to a single toggle with a 60-minute timer switch. All switches shall be wired to the unit control panel. All switch boxes shall include a GFCI convenience receptacle. Lights and GFCI receptacles shall be wired so they are functional whether the main power disconnect is in the on or off position. A separate disconnect shall be provided for the lighting and GFCI receptacles. All exterior electrical boxes shall be metallic NEMA 3R.
4. The AHU manufacturer shall supply and mount all dampers with actuators mounted and wired by EMS control contractor.
5. Although many sensors and devices shall be field mounted and wired by the site control vendor ESC, the fan arrays and condenser section along with associated electronic expansion valves, hot gas reheat valves and such shall be fitted with monitored by and controlled by factory provided controls. The factory control System shall be fully compatible with the Building Automation System via native BACnet, Modbus and N2 communication. Coordinate interface protocol with campus control vendor ESC however, as a minimum, BacNet interface shall be considered basis of design. Factory controller must be capable to flushing hot gas reheat coil as required to prevent oil build-up.

N. UNIT TESTING AND QUALITY CONTROL

1. The fans shall be factory run tested to insure design integrity and proper RPM. All electrical circuits shall be tested to ensure correct operation before shipment of unit. Units shall pass all quality control checks and be thoroughly cleaned prior to shipment.

O. AIR COOLED CONDENSER HEAT PUMP – VRF (SEE ALSO VRF HEAT PUMPS)

1. Basic Construction: Frame shall consist of heavy gauge galvanized steel with 3 mil powder coat paint, construction baked at 350° for resilience in transport and installation. Color selection shall be custom as selected by the Architect. Condenser must have base with cutouts for forklift or pallet jack. Condensing unit shall be a separate physical

component from the air handling section of the unit (i.e. not built as part of the air handling section).

2. Refrigeration Circuit: Each independent circuit shall consist of An inverter scroll compressor, thermostatic expansion valve for refrigerant metering, sight glass, filter drier, solenoid valve, reversing valves, high and low pressure controls and safety controls.

3. Coils shall include aluminum fins mechanically bonded to enhanced copper tubes with integral sub cooling circuits and rated for 650 psig.

4. Condenser fan(s) shall be direct drive axial type with high efficiency EC motors for head pressure control. Condenser fans shall be ultra-quiet with outlet designed fan blades.

5. Compressors: Unit shall contain multiple inverter scroll or rotary compressors with one compressor for each 12-ton increment all of which must be variable speed inverter type, independently circuited and mounted with rubber isolated compressor mounts to the module base. Compressors shall be configured so as to allow for a minimum turn-down of no greater than 10%. Hot gas bypass shall not be allowed. Unit manufacturer must coordinate required staging scenario with the EMS vendor to insure all required minimum on and off times and compressor rotation are adhered too. Factory controls must include all compressors safeties including compressor oil system flush cycles for reheat coils. Compressor condenser sections and matching DX cooling and reheat coils shall be configured to insure stable DX cooling and reheat operation down to 10% of the rated supply airflow. Manufacturer may segment the matching DX coils in varying capacities to achieve this for example one DX coil at 1/3 capacity and other DX coil at 2/3 capacity or other variation as predicated by the manufacturer to insure adequate airflow velocity across operating coil at minimum 10% unitary airflow realizing that the inactive idle coil shall be dampered off at low airflows as specified in the sequence of operation.

6. All suction, hot gas and vapor refrigerant piping shall be fully insulated from the condenser through to the air handler coils including piping running within the air handler in accordance with pipe insulation sections of this specification.

7. If scheduled provide hot gas reheat circuit and control with modulating hot gas reheat valves. Controller shall include hot gas flush cycle to ensure flushing of refrigerant oil that has migrated into reheat coil. Hot gas reheat circuit and matching hot gas reheat coils shall be sized to reheat air off the DX cooling coils from design leaving air temperature of no higher than 50°F to a minimum of 70°F at all operating airflows.

P. AIR COOLED CONDENSER CONTROL SYSTEM

1. Control System shall be fully compatible with the Building Automation System via native BACnet, Modbus and N2 communication. Coordinate interface protocol with campus control vendor ESC however as a minimum BacNet interface shall be considered basis of design.
2. Safety controls shall be provided with unit - High compressor motor temperature, Electrical phase failure, Compressor discharge temperature, Compressor suction temperature.

Q. ACCESSORIES

1. Voltage/Phase Monitor – protects against voltage fluctuations, phase loss and phase reversal.
2. Compressor sound blankets

3. Provide Bi-polar ionizers located downstream of the supply fans as specified elsewhere with this specification.
4. Provide UV-C light mounted at the inlet of the DX cooling coil.

PART 3 – EXECUTION: CUSTOM ROOFTOP DOAS UNITS

A. INSTALLATION

1. Install in strict accordance with manufacturer's requirements, shop drawings, and Contract Documents.
2. Equipment rigging and assembly to be supervised by the manufacturer or a manufacturer certified service organization. Provide for as long a period of time as is necessary to ensure proper assembly or onsite training but no less than 2 full days.
3. Adjust in alignment on concrete foundations, sole plates or other supporting structure. Level, grout, and bolt in place.
4. Coordinate electrical installation with electrical contractor.
5. Coordinate controls with control contractor. EMS controls contractor shall be given access to the units within the local riggers yard for a minimum of 2-weeks prior to the units being delivered on site to facilitate installation of various controllers, devices, wiring and sensors.
6. Provide all appurtenances required ensuring a fully operational and functional system.
7. Mechanical contractor is responsible for assembly of the units on site and furnishing and installing all materials to make for a complete and fully operational system including but not limited to all interconnecting refrigerant piping, refrigerant, interconnecting power wiring (performed by a licensed electrician), control wiring, etc… It shall be noted that the main power panel, control panel and rain hood are shipped loose and require field installation.

B START-UP

1. Equipment start-up is to be supervised by the unit manufacturer or a manufacturer-certified service organization. Physical connections and start-up are provided by the installing contractor. The start-up engineer shall conduct such operating tests as required to ensure that the unit is operating in accordance with design. Complete testing of all safety and emergency control devices shall be made. The start-up engineer shall submit a written report to the owner and manufacturer containing all test data recorded as required above and a letter certifying that the unit is operating properly.
2. Provide complete Operation & Maintenance Manuals with descriptive literature, model, and serial number of all equipment, performance data, manufacturer's instructions for operating and maintenance, lubrication recommendation and schedule, and winter shutdown procedure.

2.29 PACKAGED ROOFTOP COOLING/HEATING UNITS (RTU's)

A. Unit Certifications: Unit shall be certified in accordance with UL Standard 1995/CSA C22.2 No. 236, Safety Standard for Heating and Cooling Equipment. Unit and refrigeration system shall comply with ASHRAE 15, Safety Standard for Mechanical Refrigeration. Unit Energy Efficiency Ratio (EER) and heating COP shall be equal to or greater than prescribed by ASHRAE 90.1, Energy Efficient Design of New Buildings

except Low-Rise Residential Buildings and IECC 2018. Unit shall be safety certified by ETL and be ETL US and ETL Canada listed. Unit nameplate shall include the ETL/ETL Canada label. Unit and components shall be designed, manufactured, and independently analyzed, rated, and certified to meet with the seismic compliance standards of the International Building Code, 2015 edition. If requested, unit shall be provided with Certificate of Compliance from an independent certifying Professional Engineer clearly indicating that the unit and components meet seismic design requirements.

B. Submittals: Product Data: Literature shall be provided that indicates dimensions, operating and shipping weights, capacities, ratings, fan performance, filter information, factory supplied accessories, electrical characteristics and connection requirements. Installation, Operation and Maintenance manual with startup requirements shall be provided. Shop Drawings: Unit drawings shall be provided that indicate assembly, unit dimensions, construction details, clearances, and connection details. Computer generated fan curves for each fan shall be submitted with specific design operation point noted. Wiring diagram shall be provided with details for both power and control systems and differentiate between factory installed and field installed wiring.

C. Warranty: Manufacturer shall provide a “parts only” warranty for a period of 12 months from the date of equipment startup or 18 months from the date of shipment, whichever is less. Contractor shall provide full parts and labor warranty during this time period but no less than 12 months from the point of project substantial completion as determined by the project Architect. Factory warranty shall cover material and workmanship that prove defective, within the specified warranty period, provided manufacturer’s written instructions for installation, operation and maintenance have been followed. Warranty excludes parts associated with routine maintenance, such as belts and air filters. Refer to 3 year parts and labor warranty requirement for this equipment elsewhere in the spec.

D. Products shall be provided by the following manufacturers:

1. Valent or approved equal by Daikin or McQuay.

2. Substitute equipment may be considered for approval that includes at a minimum:

1. Units must be heat pumps with inverter compressor technology.

2. R-410A refrigerant

3. Direct drive supply and exhaust fans

4. Double wall cabinet construction

5. Insulation with a minimum R-value of 13

6. Stainless steel drain pans

7. Hinged access doors with lockable handles

8. Variable capacity inverter duty scroll or rotary compressors allowing 10-100% capacity turn-down in both heating and cooling mode.

9. Hot gas reheat dehumidification coil.

10. Hot water coil downstream of the supply fan.

11. Total energy recovery wheel as specified.

12. Airflow measuring stations on the exhaust fan, supply fan and outdoor air intake. Flow stations on outdoor air sections shall be used for monitoring only as OA calculations shall be determined by SA and RA flow stations.

13. All other provisions of the specifications must be satisfactorily addressed

14. Integral smoke detectors compatible with the building fire alarm system.

15. It is the intent of this project that most of the HVAC equipment such as rooftop units shall come with EMS ready controls with most controls and devices provided by the EMS for field installation. Packaged units shall come with refrigeration side condenser controls as well as fan and wheel drives and modulating actuators. Compressor controller shall be furnished by the equipment manufacturer but must be interfaced via terminal strip communication and BacNet for control and monitoring by the EMS.

E. Packaged rooftop heat pump units shall include compressors, evaporator coils, filters, supply fans, dampers, air-cooled condenser coils, condenser fans, hot gas reheat coil, hot water coil, exhaust fans, energy recovery wheels, and unit condenser controls. Unit shall be factory assembled and tested including leak testing of the coils, pressure testing of the refrigeration circuit, and run testing of the completed unit. Run test report shall be supplied with the unit in the controls compartment's literature pocket. Unit shall have decals and tags to indicate lifting and rigging, service areas and caution areas for safety and to assist service personnel. Unit components shall be labeled, including pipe stub outs, refrigeration system components and electrical and controls components. Estimated sound power levels (dB) shall be shown on the unit ratings sheet.

F. Installation, Operation and Maintenance manual shall be supplied within the unit. Laminated color-coded wiring diagram shall match factory installed wiring and shall be affixed to the interior of the control compartment's access door. Unit nameplate shall be provided in two locations on the unit, affixed to the exterior of the unit and affixed to the interior of the control compartment's access door.

G. General Construction:

1. All cabinet walls, access doors, and roof shall be fabricated of double wall, impact resistant, rigid polyurethane foam panels. Unit insulation shall have a minimum thermal resistance R-value of 13. Foam insulation shall have a minimum density of 2 pounds/cubic foot and shall be tested in accordance with ASTM D-1929 for a minimum flash ignition temperature of 610°F. Unit construction shall be double wall with G90 galvanized steel on both sides and a thermal break with no metal path from inside to outside the cabinet. Double wall

construction with a thermal break prevents moisture accumulation on the insulation, provides a cleanable interior, prevents heat transfer through the panel, and prevents exterior condensation on the panel.

2. Unit shall be designed to reduce air leakage and infiltration through the cabinet. Cabinet leakage shall not exceed 1% of total airflow when tested at 3 times the minimum external static pressure provided in AHRI Standard 340/360. Panel deflection shall not exceed L/240 ratio at 125% of design static pressure, at a maximum 8 inches of positive or negative static pressure, to reduce air leakage. Deflection shall be measured at the midpoint of the panel height and width. Continuous sealing shall be included between panels and between access doors and openings to reduce air leakage. Refrigerant piping and electrical conduit through cabinet panels shall include sealing to reduce air leakage.

3. Roof of the air tunnel shall be sloped to provide complete drainage. Cabinet shall have rain break overhangs above access doors.

4. Access to filters, dampers, cooling coils, reheat coil, heaters, supply fans, exhaust fans, return fans, energy recovery wheels, compressors, water-cooled condensers, and electrical and controls components shall be through hinged access doors with quarter turn, zinc cast, lockable handles. Full-length stainless-steel piano hinges shall be included on the doors.

5. Exterior paint finish shall be capable of withstanding at least 2,500 hours, with no visible corrosive effects, when tested in a salt spray and fog atmosphere in accordance with ASTM B 117-95 test procedure. Unit shall have custom color as selected by the Architect on entire exterior of unit.

6. Units with cooling coils shall include double sloped 304 stainless steel drain pans.

7. Unit shall be provided with base discharge and return air openings. All openings through the base pan of the unit shall have upturned flanges of at least 1/2 inch in height around the opening.

8. Roof curb shall be seismically restrained vibration isolating type with 2” static deflection springs. Curbs shall have an overall height of no greater than 24”.

9. All piping shall rise up within the unit curb and be housed within the insulated unit or within an integral insulated pipe chase. Exposed piping outside the unit shall not be allowed.

H. Electrical

1. Unit shall be provided with standard power block for connecting power to the unit.

2. Unit shall be provided with factory installed and factory wired, non-fused disconnect switch.

3. Unit shall be provided with factory installed and factory wired 115V, 13 amp GFI outlet with outlet disconnect switch in the unit control panel.

4. Unit shall be provided with phase and brown out protection which shuts down all motors in the unit if the electrical phases are more that 10% out of balance on voltage, the voltage is more that 10% under design voltage, or on phase reversal.

5. Unit shall be provided with manual reset low temperature limit controls which shut off the unit when the discharge temperature reaches a field adjustable setpoint.

6. Unit shall be provided with blower auxiliary contacts on the low voltage terminal block which close when the supply fans are energized.

7. Unit shall be provided with remote stop/start terminals which require contact closure for unit operation. When these contacts are open the low voltage circuit is broken and the unit will not operate.

8. For all RTU'S with a scheduled capacity of 2,000 CFM or greater, duct smoke detectors shall be furnished by the Electrical Subcontractor and given to the Mechanical Subcontractor for installation by the factory. The duct smoke detectors shall be wired by the Electrical Subcontractor.

I. Supply Fans

1. Unit shall include direct drive, unhoused, backward curved, plenum supply fans.

2. Blowers and motors shall be dynamically balanced and mounted on rubber isolators.

3. Motors shall be premium efficiency ODP with ball bearings rated for 200,000 hours service with external lubrication points.

4. Variable frequency drives shall be factory wired and mounted in the unit. Fan motors shall be premium efficiency.

5. Each motor shall be provided with a shaft grounding device to harmlessly bleed potential induced shaft voltages to ground.

J. Exhaust Fans

1. Exhaust dampers shall be sized for 100% relief.

2. Fans and motors shall be dynamically balanced.

3. Motors shall be premium efficiency ODP with ball bearings rated for 200,000 hours service with external lubrication points. ECM motor are allowed and preferred as available.

4. Access to exhaust fans shall be through double wall, hinged access doors with quarter turn handles.

5. Unit shall include direct drive (belt drive only allowed pending submittal review), unhoused, backward curved, plenum exhaust fans.

6. Variable frequency drives shall be factory wired and mounted in the unit. Fan motors shall be premium efficiency.

7. Each motor shall be provided with a shaft grounding device to harmlessly bleed potential induced shaft voltages to ground.

K. Cooling/Heat Pump Heating Coils

1. Evaporator & Heat Pump Mode Coils

a. Coils shall be designed for use with R-410A refrigerant and constructed of copper tubes with aluminum fins mechanically bonded to the tubes and galvanized steel end casings. Fin design shall be sine wave rippled.

b. Coils shall have interlaced circuitry and shall be standard (6 row high) capacity.

c. Coils shall be helium leak tested.

d. Coils shall be furnished with a factory installed electronic thermostatic expansion valves (duel for heat pump service see schedule).

L. Refrigeration System

1. Unit shall be factory charged with R-410A refrigerant and be configured as a heat pump.

2. Compressors shall be scroll type with thermal overload protection, independently circuited, and carry a 5 year non-prorated warranty.

3. Compressors shall be mounted in an isolated service compartment which can be accessed without affecting unit operation. Lockable hinged compressor access doors shall be fabricated of double wall, rigid polyurethane foam insulated panels to prevent the transmission of noise outside the cabinet.

4. Compressors shall be isolated from the base pan with the compressor manufacturer’s recommended rubber vibration isolators, to reduce any transmission of noise from the compressors into the building area.

5. Each refrigeration circuit shall be equipped with thermostatic expansion valve type refrigerant flow control.

6. Each refrigeration circuit shall be equipped with automatic reset low pressure and manual reset high pressure refrigerant safety controls, Schrader type service fittings on both the high pressure and low pressure sides, and factory installed liquid line filter driers.

7. Unit shall include a variable speed inverter scroll or rotary compressor on the lead refrigeration circuit(s) which shall be capable of modulation from 10-100% of its capacity.

8. Refrigeration circuit(s) shall be provided with hot gas reheat coil, modulating valves, electronic controller, supply air temperature sensor and a dehumidification control

signal terminal which allow the unit to have a dehumidification mode of operation, which includes supply air temperature control to prevent supply air temperature swings and overcooling of the space.

9. Condenser fans shall all be ECM or inverter variable speed style with adjustable compressor lockout to allow cooling operation down to 35°F.

10. Units shall have reversing valve(s) for heat pump cycle mode.

M. Condensers

1. Air-Cooled Condenser

a. Condenser fans shall be vertical discharge, axial flow, direct drive fans.

b. Coils shall be designed for use with R-410A refrigerant and constructed of copper tubes with aluminum fins mechanically bonded to the tubes and aluminum end casings. Fin design shall be sine wave rippled.

c. Coils shall be designed for a minimum of 10°F of refrigerant sub-cooling.

d. Coils shall be helium leak tested.

e. Condenser fans shall be inverter controlled for improved performance and low sound.

N. Heating Coils

1. Hot Water Heating Coils

a. Coils shall be certified in accordance with ARI Standard 410 and be leak tested.

b. Coil shall be constructed of copper tubes with aluminum fins mechanically bonded to the tubes and galvanized steel end casings. Fin design shall be sine wave rippled.

c. Coil shall have single (half) serpentine circuitry, 1 (2) rows, and 8 (10) (12) fins per inch. Rows and fins as required to achieve performance specified.

d. Coil shall be located in the reheat position downstream of the supply fans.

e. Control valves shall be field supplied and field installed.

O. Filters

1. MERV 8 filters shall be provided on the exhaust air stream upstream of energy wheel exhaust, in the outdoor airstream upstream of the energy wheel intake. High efficiency MERV 13 rigid mini-pleat filters shall be provide upstream of the unit coils and shall be 4” deep, totally rigid and disposable type. Each filter shall consist of water-laid micro fine fiberglass media formed with closely spaced pleats. The enclosing frame shall be double walled water-resistant. The filter media shall have

an average efficiency of MERV 13 as rated by ASHRAE Standard 52.1 test methods. Provide filters for start-up and flush out and post flushout.

P. Outside Air/Economizer

1. Unit shall include 0-100% economizer consisting of a motor operated outside air damper and return air damper assembly constructed of extruded aluminum, hollow core, airfoil blades with rubber edge seals and aluminum end seals. Damper blades shall be gear driven and designed to meet smoke damper Class-1 leakage specifications in accordance with U.L. 555S at 4 inches w.g. air pressure differential across the damper. Damper assembly shall be controlled by spring return enthalpy activated fully modulating actuator. Unit shall include outside air opening bird screen, outside air hood with rain lip and barometric relief dampers. Provide cleanable and removable moisture eliminators on intake air hoods.

Q. Energy Recovery (see schedules for wheel info. however, all RTU's shall have energy recovery wheels except for the kitchen make-up air unit).

1. Unit shall contain a factory mounted and tested energy recovery wheel(s). The energy recovery wheel(s) shall be mounted in a rigid frame containing the wheel drive motor, drive belt, wheel seals and bearings. Frame shall slide out for service and removal from the cabinet.

2. The energy recovery component shall incorporate a rotary wheel in an insulated cassette frame complete with seals, ECM drive motor and drive belt.

3. Wheels shall be wound continuously with one flat and one structured layer in an ideal parallel plate geometry providing laminar flow and minimum pressure drop-to-efficiency ratios. The layers shall be effectively captured in stainless steel wheel frames or aluminum and stainless-steel segment frames that provide a rigid and self-supporting matrix.

4. Wheels shall be provided with removable energy transfer matrix. Wheel frame construction shall be a welded hub, spoke and rim assembly of stainless, plated and/or coated steel and shall be self-supporting without matrix segments in place. Segments shall be removable without the use of tools to facilitate maintenance and cleaning. Wheel bearings shall be selected to provide an L-10 life in excess of 400,000 hours. Rim shall be continuous rolled stainless steel and the wheel shall be connected to the shaft by means of taper locks.

5. All diameter and perimeter seals shall be provided as part of the cassette assembly and shall be factory set. Drive belts of stretch urethane shall be provided for wheel rim drive without the need for external tensioners or adjustment.

6. The energy recovery cassette shall be an Underwriters Laboratories Recognized Component for electrical and fire safety. The wheel drive motor shall be an Underwriters Laboratory Recognized Component and shall be mounted in the cassette frame and supplied with a service connector or junction box. Thermal performance shall be certified by the manufacturer in accordance with ASHRAE Standard 84, Method of Testing Air-to-Air Heat Exchangers and AHRI Standard 1060, Rating Air-to-Air Energy Recovery Ventilation Equipment. Cassettes shall be listed in the ARI Certified Product. Wheel effectiveness must meet the conditions

specified in the schedules but in no case shall sensible effectiveness and total energy effectiveness be less than 70%.

7. Energy recovery wheel cassette shall carry a 5 year non-prorated warranty.

8. Unit shall include 2" MERV 8 pre-filters and 4 inch thick, pleated panel outside air filters with an ASHRAE efficiency of MERV rating of 13, upstream of the wheels. Unit shall include 2 inch thick, pleated panel exhaust air filters with an ASHRAE efficiency of 30% and MERV rating of 8, upstream of the wheels. Provide 4 spare sets in addition to those required during building flush-out period.

9. Hinged service access door shall allow access to the wheel(s).

10. Total energy recovery wheels shall be coated with silica gel desiccant permanently bonded by a process without the use of binders or adhesives, which may degrade desiccant performance. The substrate shall be lightweight polymer and shall not degrade nor require additional coatings for application in marine or coastal environments. Coated segments shall be washable with detergent or alkaline coil cleaner and water. Desiccant shall not dissolve nor deliquesce in the presence of water or high humidity.

11. Unit shall include a variable speed wheel to support both economizer and energy recovery wheel defrost control which includes an adjustable temperature sensor and wheel pressured sensor which, when frost is detected, slows allowing warm exhaust air to defrost the wheel. Wheel bypass dampers shall also be provided to support economizer cooling once the wheel has fully stopped.

12. Unit shall include energy recovery wheel rotation detection sensors and a set of normally open and normally closed contracts for field indication of wheel rotation.

13. Section shall include bypass recirculation damper as well as wheel OA and EA bypass dampers.

R. Manufacturer must provide grommetted and sealed test ports for temperature and pressure readings between each unit section element, such as filters, coils, energy recovery wheels, dampers and fans

S. Accessories

1. Provide Bi-polar ionizers located downstream of the supply fans as specified elsewhere with this specification.

2. Provide UV-C light mounted at the inlet of the DX cooling coils.

T. Controls

1. Factory Installed and Factory Provided Controller

a. It is the intent of this project that most of the HVAC equipment such as rooftop units shall come stripped of most controls and devices for field installation of sensors. Actuators and devices all provided by the EMS vendor. On rooftop equipment the only exception would be the compressor controller which would

be furnished by the equipment manufacturer but must be interfaced with for control by the EMS.

b. Factory controller for condensing section of the unit (i.e. compressors and condenser fans) must be capable to of controlling all features of this section with external information provided by EMS system such as supply air temperature reset and hot gas control. Controller shall be factory installed in the unit controls compartment and factory tested. Controller must be capable or flushing hot gas reheat coil to prevent oil migration into hot gas coil. Refer to ATC article for points which must come with the units from the factory.

c. Controller shall include non-volatile memory to retain all programmed values, without the use of an external battery, in the event of a power failure.

d. Suction pressure sensors shall be factory installed. Supply air temperature and space humidity setpoints, for the dehumidification mode of operation, shall be adjustable.

e. Units shall be provided with the following minimum control devices or components installed from the factory (or field installed as noted):

- Condenser section controller for full control of the refrigeration side of the unit inclusive but not limited to control of compressors, condenser fans, hot gas reheat valve, reheat coil flush, suction pressure sensors, low and high refrigerant and temperature limits, time on and off delays and voltage and phase protection.

- Fully modulating outdoor air, return air and recirculation damper actuators. Normally closed outdoor air damper.

- 2-position normally close energy wheel OA and EA bypass dampers.

- Supply and exhaust fan(s) ECM or VFD drives.

- Energy recovery wheel drive ECM or VFD drive

- Energy wheel rotation sensor.

- Fan mounted supply and exhaust airflow stations. Airflow stations which require probes to cross the inlet cone of the fan shall <u>not</u> be allowed as they impact the performance of the fan. Airflow station shall be similar to Greenheck Sure-Aire or approved equal by unit fan manufacturer and shall monitor the pressure difference between the fan inlet and the smallest diameter of the fan cone. Low pressure sensor orifices shall be equal spaced at the inlet cone venture and extend to termination plate on fan housing. High pressure flow probe(s) shall be mounted in the low velocity zone near the fan inlet and shall also extend to a termination plate on the fan housing. Flow station shall measure pressure differential to within +/-3%. Furnish field installed electronics package which shall be mounted and wired by EMS and shall include controller in NEMA 4 enclosure with 4 digit 0.6”

LCD display configured to read CFM. Unit shall have a 4-20 mA DC analog output signal.

- Provide factory furnished outdoor air flow station. Construction type shall vary by manufacturer but in general shall consist of a multi-point pitot or hot wire array calibrated to the free area of unit intake and capable of reading with 5% +/- accuracy down to 25% of the schedule minimum outside air volume. As these devices are generally inaccurate at low airflows and/or susceptible to prevailing winds, they shall only be used as a monitoring point with system OA calculated using the units supply airflow station and filed installed return airflow station (i.e. OA = SA-RA). OA flow station shall only be actively used should communication be lost from either the RA or SA flow stations.

- Hot water coil freeze-stat shall be factory furnished, installed at the downstream side of the hot water coil and wired back to a terminal strip. Deice shall be similar in construction to the device specified within the ATC section and shall be of the automatic reset type with manual rest via the EMS front-end.

- Cooling coil leaving air temperature sensor wired to unit condenser controller. This is in addition to the device require to be furnished and installed by the EMS.

- Outdoor air temperature sensor wired to unit condenser controller. This is in addition to the device require to be furnished and installed by the EMS.

2. Field Installed Controls: Refer to control drawings and sequence of operation points list contained with this specification section.

U. Start-Up, Commissioning & Training

1. Provide factory service/start-up technician to check, test and start equipment. Technician shall coordinate mapping of all control points with EMS contractor and commissioning of unit. Technician shall work with project commissioning agent to verify proper operation of unit. In coordination with the mechanical contractor and control contractor the factory technician shall provide Owner training of unit controls, maintenance, etc…

2.30 AIR HANDLING UNITS

A. Provide a factory fabricated modular air handling unit of the draw-thru type suitable for low-pressure operation as scheduled on the drawings and as specified herein by Daikin or approved equal by Aaon. Dimensions are critical to final acceptance. Refer to plans, schedule and space availability to verify vertical or horizontal configuration. Units shall come broken down into multiple segments as required to accommodate installation.

B. Fabricate units with cabinet and fan and coil sections. Base performance shall be on sea level conditions.

C. General:

1. The completed cabinet shall provide an air leakage of less than 1% when tested at 6" static pressure.
2. Unit specific color-coded wiring diagrams shall match the unit color-coded wiring and will be provided in both point-to-point and ladder form.
3. Diagrams shall also be laminated in plastic and permanently affixed inside the control compartment.
4. Access to filters, blower, heating section, and other items needing periodic checking or maintenance shall be through hinged access doors with quarter turn latches.
5. Hinged access doors shall have stainless steel hinges with removable pin and full perimeter gasketing and open against air pressure.
6. Unit shall have decals and tags to indicate service areas and caution areas. Installation and maintenance manuals shall be supplied with each unit.

D. Casing

1. Cabinet shall be constructed entirely of G90 galvanized steel 2 inch double wall panels with foam insulation providing a minimum R-Value of 12.5. The panel construction shall provide a thermal break to eliminate any metal conductive path through the panel. A channel base shall be provided.
2. Unit shall be provided with insulated hinged inspection doors with gasket, latch, and handle assembly for all sections.
3. Roof mounted units shall include pitched roof panels and be fully weather tight and include a baked epoxy finish coat.

E. Fans

1. The fans shall be direct drive, single width, single inlet, un-housed airfoil centrifugal plenum fans. Fans shall have all aluminum construction. Fans attached to 1760 rpm motors shall be rated for a minimum of 1800 RPM maximum speed. Fans attached to 1170 rpm motors shall be rated for a minimum of 1200 RPM maximum speed. Direct drive fans shall be directly connected to and supported by the motor shaft. Motor bearings shall be rated for 200,000 hours service and shall have external lubrication connections. Fan(s) and motor(s) shall be dynamically balanced, and the entire fan assembly mounted on spring isolators. Supply air shall be from the orientation shown on the plan. The fan module shall have an electrical control panel for the basic air handling unit. Fan motors shall be either ECM or premium efficiency heavy duty, open drip proof, service factor 1.15, operable at 208 volts, 3 phase, 60 Hz (see schedule). Motors shall be rated for variable frequency drive service and shall be capable of qualifying for a utility company rebate

   Fan module options:

   a. Fan motors shall be premium efficiency. Motors for use with VFD shall be premium efficiency inverter rated only. Motor bearings shall be ball bearing and shall have grease fittings.
   b. VFD drive shall be factory mounted and wired to the fan motor.
   c. Unit shall be provided with a factory installed and wired internal disconnect.
   d. Unit shall be provided with phase and brown out protection to shut down all motors in the unit if the phases are more than 10% out of balance on voltage, or the voltage is more than 10% under design voltage, or on phase reversal.
   e. Entire supply and return fan motor and drive assembly shall be mounted on an internally isolated rail system within the air handling unit cabinet. Isolators shall be spring type with minimum 1.5” deflection seismically rated. In addition,

spring/neoprene thrust isolators and flexible neoprene/glass fabric isolators shall be provided.

f. Provide self-aligning grease lubricated ball or roller bearings with extended lubrication lines to the exterior of the unit. All bearings shall perform to 200,000 hours average life.

F. Coils

1. Provide coil section with coils and access to both sides of coils. Provisions shall be made for coil removal.
2. Water coils shall be copper tube with aluminum fins of the rows and circuiting called for on the drawings. Coils shall be factory tested for the service and pressure intended. All coils shall be rated per ARI standard 410. Each cooling coil shall have a double wall sloped stainless steel condensate pan with drain connection.
3. DX cooling/heat pump and hot gas reheat coils shall be rated by ARI and pressure tested to 2,000 psi.

G. Filters

1. Provide pleated 2” thick MERV 8 filters on the return air inlet to the unit and both pleated 2” thick MERV 8 pre-filters and 4” thick MERV 14 cartridge filters on the OA intake. Provide four (4) full replacement sets (in addition to the set which shall come with the unit) for each AHU of the MERV indicated as manufactured by Farr or equal by AAF. Spare sets of air filters shall be in addition to those required and used for building flush out.

R. Energy Recovery

1. Unit shall contain a factory mounted and tested energy recovery wheel(s). The energy recovery wheel(s) shall be mounted in a rigid frame containing the wheel drive motor, drive belt, wheel seals and bearings. Frame shall slide out for service and removal from the cabinet.

2. The energy recovery component shall incorporate a rotary wheel in an insulated cassette frame complete with seals, drive motor and drive belt.

3. Wheels shall be wound continuously with one flat and one structured layer in an ideal parallel plate geometry providing laminar flow and minimum pressure drop-to-efficiency ratios. The layers shall be effectively captured in stainless steel wheel frames or aluminum and stainless steel segment frames that provide a rigid and self-supporting matrix.

4. Wheels shall be provided with removable energy transfer matrix. Wheel frame construction shall be a welded hub, spoke and rim assembly of stainless, plated and/or coated steel and shall be self-supporting without matrix segments in place. Segments shall be removable without the use of tools to facilitate maintenance and cleaning. Wheel bearings shall be selected to provide an L-10 life in excess of 400,000 hours. Rim shall be continuous rolled stainless steel and the wheel shall be connected to the shaft by means of taper locks.

5. All diameter and perimeter seals shall be provided as part of the cassette assembly and shall be factory set. Drive belts of stretch urethane shall be provided for wheel rim drive without the need for external tensioners or adjustment.

6. The energy recovery cassette shall be an Underwriters Laboratories Recognized Component for electrical and fire safety. The wheel drive motor shall be an Underwriters Laboratory Recognized Component and shall be mounted in the cassette frame and supplied with a service connector or junction box. Thermal performance shall be certified by the manufacturer in accordance with ASHRAE Standard 84, Method of Testing Air-to-Air Heat Exchangers and AHRI Standard 1060, Rating Air-to-Air Energy Recovery Ventilation Equipment. Cassettes shall be listed in the ARI Certified Product. Wheel effectiveness must meet the conditions specified in the schedules but in no case shall sensible effectiveness and total energy effectiveness be less than 70%.

7. Energy recovery wheel cassette shall carry a 5-year non-prorated warranty.

8. Hinged service access door shall allow access to the wheel(s).

9. Total energy recovery wheels shall be coated with silica gel desiccant permanently bonded by a process without the use of binders or adhesives, which may degrade desiccant performance. The substrate shall be lightweight polymer and shall not degrade nor require additional coatings for application in marine or coastal environments. Coated segments shall be washable with detergent or alkaline coil cleaner and water. Desiccant shall not dissolve nor deliquesce in the presence of water or high humidity.

10. Unit shall include energy recovery wheel rotation detection sensors and a set of normally open and normally closed contracts for field indication of wheel rotation.

11. Section shall include a full recirculation damper as well as wheel OA and EA bypass dampers.

12. Wheel shall have a variable speed motor and drive so as to adjust wheel speed to support economizer and defrost capability.

H. Accessories

1. All dampers shall be low leakage type with extruded aluminum hollow core blades with rubber edge seals and aluminum end seals rated for no more that 3CFM per SF leakage at 1”w.g
3. All AHU’s shall have integral or externally mounted VFD’s as required by the space clearances, coordinate with electrical contractor. All drives shall be manufactured by ABB. See Variable Frequency Drive article in this specification for additional performance requirements.
5. Provide disconnect switches for each fan and piece of equipment weather proof where exposed to the weather.
6. Provide two (2) full replacement sets of energy wheel drive belts and fan belts (where applicable).

J. Air handlers shall be provided with the following section configuration. Refer to the plans, schedules and information contained within these specifications for additional requirements. Plans show desired duct discharge/inlet configuration and piping left or right hand orientation.

- AHU's: O.A./R.A. Mixing Damper Box with angle filters, Exhaust Box, Return Fans, Energy Recovery Section, DX coil, access sections as shown on plans and required, Hot Water Coil, Supply Fan. Supply fans and return fans shall incorporate airflow Piezometer ring flow stations measuring stations of the hot wire type for of manuf. fan station for improved accuracy. In addition, provide full perimeter base curb.

K. For all AHU'S with a scheduled capacity of 2,000 CFM or greater, duct smoke detectors shall be furnished by the Electrical Subcontractor and given to the Mechanical Subcontractor for installation. The duct smoke detectors shall be wired by the Electrical Subcontractor, mechanical contractor shall wire to unit control circuit.

L. Start-Up and Commissioning

Provide factory service/start-up technician to check, test and start equipment. Technician shall coordinate mapping of all control points with EMS contractor and commissioning of unit. Technician shall work with project commissioning agent to verify proper operation of unit. In coordination with the HVAC subcontractor and control contractor the factory technician shall provide Owner training of unit controls, maintenance, etc…

2.31 AIR COOLED HEAT PUMP CONDENSER ACCU-1 FOR AHU-1

A. Basic Construction: Frame shall consist of heavy gauge galvanized steel with 3 mil powder coat paint, construction baked at 350° for resilience in transport and installation. Color selection shall be custom as selected by the Architect. Condenser must have base with cutouts for forklift or pallet jack.

B. Refrigeration Circuit: Each independent circuit shall consist of a scroll compressor, thermostatic expansion valve for refrigerant metering, sight glass, filter drier, solenoid valve, hot gas reheat valve, high and low pressure controls and safety controls.

C. Coils shall include aluminum fins mechanically bonded to enhanced copper tubes with integral sub cooling circuits and rated for 650 psig.

D. Condenser fan(s) shall be direct drive axial type with high efficiency EC motors for head pressure control. Condenser fans shall be ultra-quiet with outlet designed fan blades.

E. Compressors: Unit shall contain no less than two (2) scroll style compressors on variable frequency inverters, independently circuited and mounted with rubber isolated compressor mounts to the module base. Compressors shall be configured so as to allow for a minimum turn-down of no greater than 10%. Hot gas bypass shall not be allowed. Unit manufacturer must coordinate required staging scenario with the EMS vendor to insure all required minimum on and off times and compressor rotation are adhered too. Factory controls must include all compressors safeties including compressor oil system flush cycles as required. Reversing valves shall be included to enable heat pump operation.

G. Control System shall be fully compatible with the Building Automation System via native BACnet, Modbus and N2 communication. Coordinate interface protocol with EMS control vendor however as a minimum BacNet interface shall be considered basis of design. Safety controls shall be provided with unit - High compressor motor temperature, Electrical phase failure, Compressor discharge temperature, Compressor suction temperature.

H. Accessories

1. Voltage/Phase Monitor – protects against voltage fluctuations, phase loss and phase reversal.
2. Compressor sound blankets.
3. Crankcase heaters and accessories for low temp heat pump operation.

4. Disconnect switch.

2.32 VARIABLE REFRIGERANT VOLUME AIR CONDITIONING – Three Pipe Heat Recovery and Two Pipe Heat Pump

A. This section includes the design, performance, refrigerant details, controls and installation requirements for Daikin VRV systBMS (variable refrigerant volume) or equal by LG or Mitsubishi.

1. All units shall be listed and rated by ANSI/AHRI Standard 1230-2010 and meet all minimum IEER performance requirements as scheduled.
2. The units shall be ANSI/UL STD 1995 listed and listed by Electrical Testing Labs (ETL) and bear the cETL label.
3. All wiring shall be in accordance with the National Electric Code (NEC).
4. The system will be produced in an ISO 9001 and ISO 14001 facility, which are standards set by the International Standard Organization (ISO). The system shall be factory tested for safety and function.
5. Acceptable manufacturer: Daikin, LG or Mitsubishi.
6. Units must be provided with accessories needed for stable operation down to -13F in heating mode and -4F in cooling mode.

B. SYSTEM DESCRIPTION

1. The variable capacity air conditioning system shall be a Daikin Variable Refrigerant Volume system as specified. The system shall consist of multiple evaporators, branch selector boxes, REFNET™ joints and headers, a two or three pipe refrigeration distribution system using PID control and Daikin VRV condensing unit. The condensing unit shall be a direct expansion (DX), air-cooled or water-cooled, multi-zone air-conditioning system with variable speed inverter driven scroll compressors using R-410A refrigerant. The condensing unit may connect to an indoor evaporator capacity up to 200% of the condensing unit capacity. Each zone shall be capable of operating separately with individual temperature control. Each indoor unit or group of indoor units shall be able to provide independent temperature set points via a local remote controller, a centralized Intelligent touch screen controller, or a BMS interface.
2. Standard T style joints are not acceptable for a variable refrigerant volume system. Manufacturer specific Y joints shall be supplied by the VRV manufacturer.
3. Heat Recovery

a. Operation of the system shall permit individual heating and cooling of each indoor unit simultaneously, or of all indoor units associated with each branch selector port.

b. A dedicated hot gas pipe shall be used to ensure optimum heating operation performance. Two-pipe, heat recovery systems utilizing a lower temperature mixed liquid/gas refrigerant to perform heat recovery shall provide system heating capacity at design temperature to the consultant before bidding. Capacity losses from factors such as piping lengths, defrost cycles and lower discharge air temperatures resulting from a 2-pipe only heat recovery system shall be taken into account.

c. Branch selector boxes shall be located as shown on the drawing. Each branch of the branch selector box shall consist of three electronic expansion valves. The branch selector box shall control the operational mode of the subordinate indoor units. The use of three EEV's ensures continuous heating during defrost (multiple condenser systems only), no heating impact during changeover and reduced sound levels. The use of solenoid valves for changeover and pressure equalization shall not be acceptable due to refrigerant noise.

C. VRV IV FEATURES

1. VRV system shall feature Variable Refrigerant Temperature, where the system automatically varies the target evaporating and condensing temperatures based on building load and weather conditions. The condensing unit shall also feature customizable operating modes which allows for the manual setting of target evaporating and condensing temperatures.

2. Each system shall be available with a configurator software package to allow for remote configuration of operational settings and assessment of operational data and error codes. If this software is not provided by an alternate manufacturer, the contractor shall configure the settings manually for each individual outdoor unit and keep detailed records for future maintenance purposes.

D. START-UP AND WARRANTY

1. The system must be installed by a DXS trained and certified contractor. The bidders shall be required to submit training certification proof with bid documents. Untrained contractors who wish to bid this project may contact DXS (DXS Engineering, 781-258-1002) to arrange training prior to bid day.

2. The manufacturer shall provide a factory trained service technician to start-up each unit. Manufacturer shall provide instruction to the owners' personnel on proper unit operation and maintenance. The hours of training shall not be less than 16 hours and include all operation, adjustments and maintenance aspects.

3 The warranty period on all parts and compressors shall commence on the date of initial start-up and shall continue for a period of Ten (10) years not to exceed one hundred and twenty-six (1 26) months from date of shipment. Proper maintenance of the equipment, performed by approved technicians as per the manufacturer or manufacturer's representative, shall be conducted. Maintenance logs shall be supplied by the owner upon request.

E. REFRIGERANT PIPING

1. Code Compliance

a. Installation shall conform with ASME B31.5 Mechanical Refrigeration Code.

b. Welding materials and procedures shall conform to ASME SEC 9 and applicable provincial labor regulations.

c. Safety pressure relief valves shall be field supplied and installed in the piping as per

d. Pressure relief valves shall be 600 PSI rated and installed in pairs (two valve per refrigeration circuit), and shall be supplied and installed for both the liquid and suction line as per drawing details. Pressure relief valves shall be individually isolated to allow for maintenance and required replacement.

2. All systems shall display appropriate Ozone Depletion Prevention (ODP) tags prior to commissioning. VRV manufacturer shall not commission any system not displaying proper ODP tag.
3. Materials
   a. All copper piping shall be air conditioning and refrigerant grade ASTM B280 ACR.
   b. Copper piping up to and including 5/8" nominal diameter may be type L copper (and may be soft copper if supported accordingly).
   c. Copper piping above 5/8" nominal diameter shall be type K copper.
4. Brazing rods for all joints shall be 15% silfoss.
5. Approved R-410a flaring block, and approved torque wrenches, both available from VRV manufacturer, shall be used for all flare connections.
6. Y style piping joints and headers provided by the manufacturer shall be used to ensure proper refrigerant balance and flow for optimum system capacity and performance.
7. T style joints and/or joints provided by the installing contractor, or Y joints not purchased from the manufacturer shall not be acceptable.
8. Isolation valves shall be installed where shown on the schematics. Isolation valves shall be bi-flow self seating valves rated for R-410A with operating pressures up to 650 PSI. Valves shall be complete with brass shrader connections located on the valve body only.
9. Quality Assurance
10. Nitrogen purging shall be used on all brazed joints to minimize oxidization.
11. Filter dryers, sight glasses, expansion valves, solenoid valves or any other 3rd party components shall NOT be installed in the field piping.
12. Contractor shall provide VRV manufacturer with all actual pipe lengths installed for calculation of refrigerant charge. Refrigerant piping contractor shall supply and charge VRV system with required quantity of R-410a prior to VRV manufacturer commissioning. Refrigerant charging shall be done in the liquid state.
13. High/low pressure gas line, liquid and suction lines shall be individually insulated between the condensing units, branch selector units and indoor units.
    a. All indoor refrigerant lines shall be insulated with minimum ½" wall diameter Armaflex.
    b. All outdoor refrigerant lines shall be insulated with minimum ¾" wall diameter Armaflex and suitable for outdoor service. Exposed insulation shall be protected by aluminum, sheet metal, painted canvas, plastic cover, or painted with an approved UV coating that is water resistant and provides shielding from solar radiation.
    c. Pipe clamps shall fasten around the piping insulation. Pipe clamps that compress the copper directly shall be installed a minimum of 36" away from RefNet joints, and shall be loosely tightened to allow for copper expansion.
    d. Pipe supports shall be a maximum of 6' apart.

F. FAN COILS

1. Daikin units shall be designed for R-410A refrigerant and be equipped with an electronic expansion valve.
2. Computerized PID control shall be used to control superheat to deliver a comfortable room temperature condition. The unit shall be equipped with a programmed drying mechanism that dehumidifies while inhibiting changes in room temperature when used with Daikin remote control BRC1E73.
3. Indoor units shall be completely factory assembled and tested. Internal unit components shall be factory wired and piped, and complete with electronic proportional expansion valve, control circuit board, fan motor thermal protector, flare connections, condensate drain pan, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch.

    1. FXFQ_T – ROUNDFLOW CEILING CASSETTE UNIT
        a. Daikin indoor unit model FXFQ_T shall be a round flow ceiling cassette fan coil unit with direct drive DC (ECM) type fan for installation into the ceiling cavity equipped with an air panel grill. It shall be a round flow 360° air distribution type with a fresh white, impact resistant decoration panel.
        b. The supply air is distributed via four individually controlled motorized louvers. The louvers can be manually and individually adjusted for multiple configurations, without requiring blank off plates.
        c. The indoor unit shall be equipped with built-in occupancy sensor and surface temperature sensor.
        d. The indoor unit’s sound pressure shall range from 30 dB(A) to 45 dB(A) at high speed measured at 5 feet below the unit.
        e. Return air shall be through the concentric panel, which includes a resin net, mold resistant, antibacterial filter.
        f. The indoor units shall be equipped with a condensate pan with antibacterial treatment and condensate pump. The condensate pump shall provide up to 33-1/2” of lift from bottom of unit to top of drain piping and have a built-in safety shutoff and alarm.
        g. The fan type shall be direct-drive DC (ECM) with statically and dynamically balanced impeller with three fan speeds available. The DC fan shall be able to automatically adjust between 5 fan speeds based on the space load.
        h. The fan motor shall be equipped as standard with adjustable external static pressure (ESP) settings to allow operation with the high efficiency air filter options.
        i. Self-Cleaning Filter Panel, which performs automatic filter cleaning up to once a day, with dust collection box that indicates when it should be emptied.
        j. Units shall be supplied with an optional fresh air intake kit. The kit shall allow the cassette to pull fresh air directly from outdoors without the need for auxiliary fans. The kit shall then mix the fresh air with the return air before being treated by the coil. Air intake kits that do not have the ability to pull fresh air directly and to introduce it before the coil to allow mixing and conditioning by the unit shall not be acceptable.

2. FXZQ – 4 WAY CEILING CASSETTE UNIT

   a. Daikin indoor unit model FXZQ shall be a ceiling cassette fan coil unit for installation into the ceiling cavity equipped with an air panel grill. It shall be a four-way air distribution type, white, impact resistant with a washable decoration panel. The supply air is distributed via motorized louvers which can be horizontally and vertically adjusted from 0° to 90°.

   b. The indoor unit's sound pressure shall range from 29 dB(A) to 34 dB(A) at low speed measured at 5 feet below the unit.

   c. The 4-way supply air flow shall be capable of field modification to 2-way or 3-way airflow to accommodate various installation configurations including corner installations.

   d. Return air shall be through the concentric panel, which includes a resin net mold resistant filter. The indoor units shall be equipped with a condensate pan and condensate pump. The condensate pump shall provide up to 21" of lift and have a built-in safety shutoff and alarm.

   e. Three auto-swing positions shall be available to choose from, which include standard, draft prevention and ceiling stain prevention. The airflow of the unit shall have the ability to shut down one or two sides allowing for simpler corner installation.

   f. Fresh air intake shall be possible by way of direct duct installation to the side of the indoor unit cabinet.

   g. A branch duct knockout shall exist for branch ducting supply air.

   h. The fan shall be direct-drive turbo fan type with statically and dynamically balanced impeller with high and low fan speeds available.

3. FXMQ_PB – CONCEALED CEILING DUCTED UNIT

   a. Daikin indoor unit FXMQ_PB shall be a built-in ceiling concealed fan coil unit with direct-drive DC (ECM) type fan with auto CFM adjustment at commissioning for installation into the ceiling cavity. Casing shall be constructed of galvanized steel. Configuration shall be horizontal discharge air with horizontal return air, with a maximum height of 11-13/16" and be designed to fit in tight ceiling plenums.

   b. The indoor unit's sound pressure shall range from 29 dB(A) to 43 dB(A) at low speed measured 5 feet below the ducted unit.

   c. The indoor units shall be equipped with a condensate pan and condensate pump. The condensate pump shall provide up to 18-3/8" of lift from the center of the drain outlet and have a built-in safety shutoff and alarm.

   d. The fan type shall be direct-drive DC (ECM) with statically and dynamically balanced impeller with three fan speeds available, and automatically adjustable external static pressure logic (selectable during commissioning).

   e. Field installed filters and filter kits with 2" filter depth option of side or bottom access.

   f. Standard, MERV8 filters with 4 sets of filters.

4. FXAQ – WALL MOUNTED UNIT

   a. Daikin indoor unit FXAQ shall be a wall mounted fan coil unit for installation onto a wall within a conditioned space. A mildew-proof, polystyrene condensate drain pan and resin net mold resistant filter shall be included as standard equipment.

   b. The indoor unit's sound pressure shall range from 31 dB(A) to 41 dB(A) at low speed measured at 3.3 feet below and 3.3 feet away from the unit.

   c. The unit shall have an auto-swing louver which ensures efficient air distribution, which closes automatically when the unit stops. The remote controller shall be able to set five (5) steps of discharge angle. The front grille shall be easily removed for washing. The discharge angle shall automatically set at the same angle as the previous operation upon restart.

   d. The cabinet shall be affixed to a factory supplied wall mounting template and located in the conditioned space.

   e. The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.

   f. The fan type shall be direct-drive cross-flow with statically and dynamically balanced impeller with high and low fan speeds available.

   g. Units shall be provided with a loose field installed condensate pump and condensate switch.

5. FX-LQ – FLOOR CONSOLE UNIT

   a. Daikin indoor unit FXLQ shall be a floor mounted console fan coil unit for installation within a conditioned space. The cabinets can be mounted on the floor with refrigerant and condensate lines directed downward or affixed to the wall with horizontal refrigerant and condensate knockouts.

   b. FXLQ units shall be suitable for exposed installations with an ivory white finish.

   c. The indoor unit's sound pressure shall range from 35 dB(A) to 40 dB(A) at high speed measured at 5 feet away from the unit and 5 feet above floor level.

   d. Condensate draining shall be made via gravity or external condensate pump.

   e. The cabinet shall be affixed to a factory supplied wall mounting template and located in the conditioned space.

   f. The cabinet shall be constructed with sound absorbing fiberglass urethane foam insulation.

   g. Maintenance access shall be a minimum of ¾" in the rear, and 4" on the right and left sides.

   h. The fan type shall be Sirocco direct-drive with statically and dynamically balanced impeller with high and low fan speeds available.

   i. The return air shall be filtered by means of a washable long-life filter with mildew proof resin.

   j. Units shall be provided with a loose field installed condensate pump.

6. FXMQ_M – LARGE SIZE CONCEALED CEILING DUCTED UNIT

a. Daikin indoor unit FXMQ_M shall be a built-in ceiling concealed fan coil unit for installation into the ceiling cavity. Casing shall be constructed of galvanized steel and shall be available in capacities from 72,000 Btu/h to 96,000 Btu/h. The unit configuration shall be horizontal discharge air with horizontal return air.

b. The indoor unit's sound pressure shall be 48 dB(A) or less at low speed measured 5 feet below the ducted unit.

c. The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.

d. Filters are to be field supplied and installed in the ductwork by others.

e. The fan shall be direct-drive Sirocco type fan, statically and dynamically balanced impeller with high and low fan speeds available, and equipped as standard with adjustable external static pressure (ESP) settings.

f. Units shall be provided with a loose field installed condensate pump.

g. Field installed filters and filter kits with 2" filter depth option of side or bottom access.

h. Standard, MERV8 filters, set of 4 filters.

G. CONDENSING UNIT

1. The condensing unit shall be factory assembled in North America and pre-wired with all necessary electronic and refrigerant controls. The refrigeration circuit of the condensing unit shall consist of Daikin inverter scroll compressors, motors, fans, condenser coil, electronic expansion valves, solenoid valves, 4-way valve, distribution headers, capillaries, filters, shut off valves, oil separators, service ports, liquid receiver and suction accumulator.

2. The system will automatically restart operation after a power failure and will not cause any settings to be lost, thus eliminating the need for reprogramming.

3. The unit shall incorporate an auto-charging feature and a refrigerant charge check function to ensure proper refrigerant charge.

4. The following safety devices shall be included on the condensing unit: high pressure sensor and switch, low pressure sensor, control circuit fuses, crankcase heaters, fusible plug, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, over current protection for the inverter, and anti-recycling timers.

5. To ensure the liquid refrigerant does not flash when supplying to the various indoor units, the circuit shall be provided with a sub-cooling feature.

6. Oil recovery cycle shall automatically occur 2 hours after start of operation and then every 8 hours of operation.

7. The Daikin inverter scroll compressors shall be variable speed (PVM inverter) controlled which is capable of changing the speed to follow the variations in total cooling and heating load as determined by the suction gas pressure as measured in the condensing unit. In addition, samplings of evaporator and condenser temperatures shall be made so that the high/low pressures detected are read every 20 seconds and calculated. With each reading, the compressor capacity (INV frequency) shall be controlled to eliminate deviation from target value.

8. Non inverter-driven compressors, which may cause starting motor current to exceed the nominal motor current (RLA) and require larger wire sizing, shall not be allowed.
9. The inverter driven compressor in each condensing unit shall be high efficiency reluctance DC (digitally commutating), hermetically sealed scroll “G-type” or “J-type”.
10. Neodymium magnets shall be adopted in the rotor construction to yield a higher torque and efficiency in the compressor instead of the normal ferrite magnet type. Upon complete stop of the compressor, the neodymium magnets will position the rotor into the optimum position for a low torque start.
11. The compressors’ motors shall have a cooling system using discharge gas, to avoid sudden changes in temperature resulting in significant stresses on winding and bearings.
12. Each compressor shall be equipped with a crankcase heater, high pressure safety switch, and internal thermal overload protector.
13. The compressor shall be internally isolated to avoid the transmission of vibration, eliminating the need for external spring insolation.
14. In the event of compressor failure, for condensing units with multiple compressors, the remaining compressors shall continue to operate and provide heating or cooling as required at a proportionally reduced capacity. The microprocessor and associated controls shall be designed to specifically address this condition.
15. In the case of multiple condenser modules, conjoined operation hours of the compressors shall be balanced by means of the Duty Cycling Function, ensuring sequential starting of each module at each: start/stop cycle, completion of oil return, completion of defrost, or every 8 hours of operation, extending the operating life of the system. When connected to a central control system, sequential start is activated for all systems on each DIII network.
16. The unit shall be constructed from rust-proofed mild steel panels coated with a baked enamel finish. The unit shall be modular in design and shall allow for side-by-side installation with minimum spacing requirements.
17. Condensing Unit Stand:

    Provide 18” high seismic rated snow stand similar to Quick-Sling VRF/VRV Super Stand product or equal securely fastened to the anchored roof sleepers and the unit. Provide additional anchors and stiffeners for seismic restraints. Provide neoprene vibration isolators.

18. Air Cooled
    a. The fan motor shall have inherent protection and permanently lubricated bearings. The motor shall be provided with a fan guard to prevent contact with moving parts. The condensing unit shall consist of one or more propeller type, direct-drive 350 or 750 W fan motors that have multiple speed operation via a DC (digitally commutating) inverter. Motors shall be capable of delivering design air at high external static pressures up to 0.32 in WG (factory set as standard at 0.12 in. WG) to accommodate field applied duct for indoor mounting of condensing units.
    b. Night setback control of the fan motor for low noise operation by way of automatically limiting the maximum speed shall be a standard feature.

c. The condenser coil shall be manufactured from copper tubes expanded into aluminum fins to form a mechanical bond. The heat exchanger coil shall be of a waffle louver fin and rifled bore tube design to ensure high efficiency performance.

d. The heat exchanger on the condensing units shall be manufactured from Hi-X seamless copper tubes with N-shape internal grooves mechanically bonded on to aluminum fins to an e-Pass Design. The fins are to be covered with an anti- corrosion acrylic resin and type E1 hydrophilic film.

e. The fins are to be covered with an anti-corrosion Ultra Gold coating as standard with a salt spray test rating of 1000hr (ASTM B117 & Blister Rating:10), Acetic acid salt spray test of 500hr (ASTM G85 & Blister Rating:10).

f. The pipe plates shall be treated with powdered polyester resin for corrosion prevention. The thickness of the coating must be between 2.0 to 3.0 microns.

g. The outdoor coil shall have three-circuit heat exchanger design. The lower part of the coil shall be used for inverter cooling and be on or off during heating operation, enhancing the defrost operation.

19. Heat Pump

a. The outdoor unit shall be capable of heating operation at -4°F ambient temperature. Tested factory data on heating capacity and efficiency shall be available.

b. The outdoor unit shall be capable of cooling operation down to +23°F without any additional low ambient controls.

c. The outdoor unit shall be complete with low ambient controls and low ambient wind baffles for cooling operation down to -4°F

20. Heat Recovery

a. The outdoor unit shall be capable of heating operation at -13°F ambient temperature. Tested factory data on heating capacity and efficiency shall be available. For multiple module systems, the system shall continue to provide heat to the indoor units in heating operation while in the defrost mode.

b. The outdoor unit shall be capable of cooling operation down to 23°F without any additional low ambient controls.

H. BRANCH SELECTOR BOX

1. Branch selector boxes shall be located as shown on the drawing. Selector box cabinets shall have a galvanized steel plate casing and shall house multiple electronic expansion valve and a sub-cooling loop. The unit shall contain sound absorption thermal insulating material made of flame and heat resistant foamed polyethylene.

2. Branch selector boxes shall not require drain pan and drain connections. Manufacturers with branch selector boxes requiring drain connections shall bid as an alternate and carry allowances to compensate for the added costs of the drain connections.

3. Manufacturers with branch selector box sizes, arrangements, or locations that differ from what is specified shall make the necessary arrangements to ensure their alternative branch selector boxes both fit in the space.

I. CONTROLS

1. Fan coil units shall be supplied with Individual Zone Controllers, similar to Daikin model BRC1E73
   a. Remote controllers shall be hard wired by installing contractor.
   b. Controllers shall be able to function as follows:
      1. The controller shall have dual or single Cool and Heat setpoints for occupied periods, and independent setback setpoints for unoccupied periods.
      2. The controller shall have the ability to digitally prohibit individual buttons and functions.
      3. The controller shall have a self diagnosis function that constantly monitors the system for malfunctions (total of 80 components).
      4. An LCD digital display will allow the temperature to be set in 1°F units.
      5. The controller shall be equipped with a thermostat sensor.
      6. The controller shall have the ability to automatically changeover the mode of operation with dual or single setpoints.
      7. Controller shall have built-in 7 day, weekday plus Saturday Sunday (5+1+1), weekday plus weekend (5+2) and everyday (1) scheduler.
      8. Controller shall have a simple display mode, displaying only the operation mode, the setpoint(s), and the room temperature.
   c. Provide an advanced multi-zone controller for installation in a common area as shown on the plans, equal to Daikin intelligent Touch Manager V2.0. The controller shall have a 10” LCD touch screen display with the following screen views and functionalities :
      1. Central control of set points, schedules, airflow rates, heat/cool mode, and of setback (override) temperature settings during unoccupied periods.
      2. Adjustable temperature limits to restrict local wall mounted thermostat set point ranges.
      3. Visible and audible alarm indication of any system malfunctions with descriptive error code.
      4. External Digital and / or Analog input/output and display of external input values.
      5. Tiered hierarchy allowing for control of fan coil units independently or as a group.
      6. Remotely disable individual functions of the wall mounted controllers.
      7. Web enabled for remote access from PC, tablet or portable device and automatic alert and error emails.
      8. Automatic changeover shall be accomplished using one of the following two algorithms:
         a) Averaging method – the central controller shall sum up the difference between room temperatures and set points for all indoor units in the system. Once this delta reaches the primary changeover deadband of ± 2°F (adjustable), the central controller shall change over the system automatically.

b) Voting Method – the averaging method shall be used for the first stage of changeover. However, if any fan coil in the system reaches the primary changeover deadband of 3°F away from set point (adjustable), the voting algorithm shall take over and changeover the system to satisfy the diverting fan coil. The voting method limits the maximum amount that a zone can deviate from set point. This maximum amount shall be adjustable.

- For both automatic change over options, a weight (0-3) can be added to each indoor unit. The automatic changeover algorithm shall use this weighting to prioritize changeover for the more heavily weighted fan coils.
- Upon any changeover, a guard timer shall prevent another changeover for a period of 15, 30, or 60 (default) minutes.
- The guard timer shall be ignored by a change of setpoint manually from either the central controller or the remote controller, by schedule, or if the secondary deadband is reached with either of the automatic changeover algorithms. The secondary changeover deadband shall be the sum of the primary changeover deadband (adjustable) ± 1°F (adjustable)

9. "3D" Floor plan graphic layout

- The central controller shall have the capability for site floor plan to be uploaded as a background to create a graphics interface. Background shall be specific project building floor plan rendered in "2D" or "3D".
- Floor plan layout shall be displayed on building control display as well as accessible from the web.
- Floor plan will include capability to control indoor unit, and auxiliary inputs / outputs, such as designated lighting control, as follows:
  i. Up to 4 status points to be assigned to the control point icon (room name, room temperature, set point, and mode).
  ii. Status and control points to display on corresponding location of zone served on floor plan.
  iii. Digital input and output icons will display On/Off status.
  iv. Analog input icons will display analog value.
- Up to 60 floor layout sections shall be possible depending on project scope.

10. Centralized controller shall be complete with power distribution software with the ability to generate .csv files with power consumption data for each fan coil in the system. With proper tenant agreement via a lease or purchase agreement, the distributed power consumption data can be used by the owner or by the billing company to assess how the power consumption of the condensing units shall be distributed to each fan coils. The energy consumption files shall be accessible from the web via a restricted security access.

11. VRV manufacturer shall provide all necessary power meters required for the power distribution software of the centralized controller. Power meters shall be Measurement Canada approved. Power meters shall be installed and wired back to the centralized controller by division 16.

12. Installing contractor shall provide a 24VAC power connection to the central controller.

a. Power Proportional Distribution (PPD)

i. The tenant billing option shall be capable of calculating VRV Controls Network equipment energy usage in kWh based on the energy consumption of the outdoor unit(s) divided among the associated indoor units. This software is used in conjunction with the intelligent Touch Manager and a Watt Hour Meter (WHM). A maximum of 3 Watt Hour Meters can be connected to the intelligent Touch Manager. Up to 4 additional Watt Hour Meters can be connected to each iTM Plus Adapter, and up to 7 iTM Plus Adapters can be connected to the intelligent Touch Manager. The Power Proportional Distribution results data can be saved to a USB flash drive, or on a PC with the use of the web access. Data is saved in the CSV format. Results can be stored up to 13 months in the intelligent Touch Manager.

2. Provide a control module to allow full integration with a BACnet IP or LonWorks compatible BMS.
   a. BACnet module shall be wired, installed and powered (24VAC) by installing contractor. IP connection shall be by BMS contractor.
   b. VRV manufacturer shall commission the BACnet panel. BMS contractor shall provide VRV manufacturer with static IP address and instance number for commissioning.
   c. All programming for monitoring and control of VRV system via the BACnet panel shall be by BMS contractor, as per the Sequence of Operation.
   d. Programmability:
      a. The BACnet building management system shall support weekly schedule settings through its programming.
         i. The schedule shall support the indoor unit:
            a. On/Off
            b. Each scheduled event shall specify time and target group
            c. Each scheduled event shall include On/Off, Operation Mode, Occupied Cooling Setpoint, Occupied Heating Setpoint, Setup (Cooling) setback setpoint, Setback (Heating) setback setpoint, Remote Controller On/Off Permit/Prohibit, Remote Controller Mode Permit/Prohibit, Remote Controller Setpoint Permit/Prohibit, and Timed Override Enable
            d. Setup (Cooling) and Setback (Heating) setpoints when unit is Off (unoccupied) by Group
            e. An override shall be provided for use enabling indoor unit operation during the unoccupied period by the BACnet building management system programming.
      b. The BACnet building management system shall support auto-changeover through its programming.
         i. Auto-change shall provide changeover for both Heat Pump and Heat Recovery systBMS based upon the group configurations. This will allow for the optimal room temperature to be maintained by automatically switching the indoor unit's mode between Cool and Heat in accordance with the room temperature and setpoint temperature.

ii. Changeover shall change the operation mode of the indoor unit that is set as the Changeover Master. The Changeover Master indoor unit shall then change the operation mode of all indoor unit groups daisy chained on the same DIII-Net communication bus to the same outdoor unit in the Heat Pump system or the same branch selector box in the Heat Recovery system.

iii. Changeover to cooling mode shall occur when the room temperature is great than or equal to the cooling setpoint

iv. Differential to be determined by BACnet building management system programming

v. Changeover to heating mode shall occur when room temperature is less than or equal to the heating setpoint.

vi. Differential to be determined by BACnet building management system programming

vii. Guard timer- Upon changeover, guard timer will prevent another changeover during this period. Guard timer should be ignored by a change of setpoint manually from the BMS, Intelligent Touch Controller, Remote Controller, or by schedule. Guard timer to be configured by BACnet building management system programming (30 minute minimum recommended)

c. The Interface for use in BACnet shall support force shutdown of associated indoor unit groups.

J. ELECTRICAL

1. The power supply to the condensing unit shall be as scheduled.
2. Independent electrical power for fan coils and branch selector boxes shall be 208/230 volts, 1 phase, 60 hertz. The unit shall be capable of operating within the limits of 187 volts to 253 volts.
3. Unless limited by local local electrical codes and standards, multiple fan coils and branch selector boxes can be connected to the same breaker. Individual disconnect switches for each fan coil are required, and are to be provided and installed by division 16.
4. Electrical power for condensing units shall be 460 volts, 3 phase, 60 hertz.
5. The control voltage between the indoor and outdoor unit shall be 16VDC non-shielded 2 conductor cable.
6. The control wiring shall be a two-wire multiplex transmission system, making it possible to connect multiple indoor units to one outdoor unit with one 2-cable wire, thus simplifying the wiring operation.
7. Control wiring shall be installed in a daisy chain configuration from indoor unit to indoor unit then to the branch selector box and outdoor unit. Control wiring shall run from the indoor unit terminal block to the specific controller for that unit.

K. EXECUTION

1. DELIVERY, STORAGE AND HANDLING

   a. Units shall be stored and handled according to the manufacturer's recommendations. Units shall be kept clean and isolated from dust and debris.

2. INSTALLATION

   a. Install condensing units on a flat surface level within 1/8 inch, and elevated a minimum of 18" from ground or roof surface. Provide intermediate supports as recommended by the equipment manufacturer.

   b. Provide all necessary control wiring as recommended by the manufacturer.

   c. High/low pressure gas line, liquid, and suction lines must be individually insulated between the outdoor and indoor units.

   d. Contact DXS (781-258-1002) prior to installation to review and confirm piping layout and lengths.

   e. Use refrigeration best practice to allow pipes to expand and contract freely. Review manufacturer installation instructions to ensure expansion joints are properly designed.

   f. Pressure test ALL systBMS to 550 PSI after system was vacuumed and held to below 500 microns for at least one hour. Review manufacturer installation instructions for proper pressure test procedures.

   g. Design and install all piping as per local code and regulations.

2.33 DUCTLESS SPLIT AIR CONDITIONING SYSTEM (non VRF)

A. Furnish and install a ductless split commercial ceiling mounted fan coil (surface mounted below ceiling) as scheduled with a roof mounted air-cooled condensing unit. Indoor unit shall be wall hung as scheduled. The system shall be rated per ARI Standard 210/240 and certified by UL and CSA. The system shall be as manufactured by Daikin, Mitsubishi, Sanyo or equal. A non-CFC or HCFC refrigerant must be used such as R-410A or approved equal. Minimum EER=16

B. The combination of the outdoor unit and the indoor-fan coil unit shall have a total net cooling capacity as scheduled on drawings or greater at conditions of entering-air temperature at the evaporator coil of 80 degrees F. dry bulb and 67 degrees F. wet bulb. Outdoor ambient temperature of air entering the condenser of 95 degrees F. The system shall have a minimum listed SEER (seasonal energy efficiency ratio) of 14 at ARI conditions.

C. Indoor Fan Coil Unit:

   1. Indoor, direct-expansion, low-profile (11-3/4 in. high) in-ceiling fan coil or wall hung as scheduled. Unit shall come complete with cooling coil, fan, fan motor, piping connectors, electrical controls, condensate pump, and hanging brackets.

   2. Cabinet shall be constructed of zinc-coated steel. Fully insulated discharge and inlet grilles shall be attractively styled, high-impact polystryrene. Cabinet shall have filter tracks and cleanable filters which shall be accessible from below with a 1/4-turn fastener. Adjacent room cooling to be provided by a simple knockout in the cabinet

side panel, and cabinet shall have provisions to accommodate a limited amount of ductwork, if desired.

3. Fan shall be a centrifugal, direct-drive blower type with air intake in center of the unit and discharge on the perimeter. Air louvers shall be adjustable.

4. Coil shall be copper tube with aluminum fins and galvanized steel tube sheets. Fins will be bonded to the tubes by mechanical expansion. A drip pan under the coil shall have a factory-installed condensate pump and drain connection for hose attachment to remove condensate. External pump shall be provided for wall units as required.

5. Motor shall be totally enclosed and permanently lubricated with inherent protection. Fan motor shall be 3-speed. Unit shall operate on single phase 60- cycle 208 V power.

6. Controls shall be 24 Volt, and shall be easily operated by the user from a wall-mounted control unit. Float control shall be in the condensate sump to shut unit down in case of pump malfunction. A wall-mounted programmable thermostat with three (3) fan speed selections, and an auto/manual switch shall be supplied for field installation. The refrigerant is controlled with a piston-type refrigerant metering device, and evaporator coil freeze protection shall be provided.

E. Outdoor Air Cooled Condensing Unit: Furnish and install matching condensing unit. Condensing unit shall have low ambient control for operation down to 0°F, hard start assist kit, winter start package, wind baffle and crankcase heater.

F. Condensing Unit Stand: Provide 18” high seismic rated snow stand similar to Quick-Sling VRF/VRV Super Stand product or equal securely fastened to the anchored roof sleepers and the unit. Provide neoprene seismic rated vibration isolators.

G. Provide Owner training on operation, adjustment and maintenance for a minimum of 8 hours.

2.34 FAN COIL UNITS

A. Provide factory fabricated fan coil units as called for on the drawings by McQuay, York, Trane or equal. Units shall be U.L. listed. Fans shall be forward curved statically and dynamically balanced. All control valves and fan relays, shut-off’s, vents and balancing valves shall be furnished by the factory or field furnished for factory or field installation. Vertical fan coil units shall either be filed supplied or come with controls and valves factory or field installed and wired. Ducted fan coil units shall be fitted with field installed controls. Coordinate fully with controls vendor prior to ordering.

B. BASIC UNIT: All fan coils shall be manufactured with heavy gauge galvanized steel to resist corrosion. All models shall be approved for installation with “0” clearance to combustible material. Piping, drain, and wiring connections are readily accessible and mounting holes and/or slots are pre-drilled to save installation time and field labor expense.

C. PLENUMS AND CABINETS: Plenums and cabinets are insulated to increase efficiency and to insure quiet operation. Exposed cabinets and access panels are coated with an attractive baked on finish. Submit color chart for review and selection. All models have throw away MERV 8 filters. Hinged panels are included with some models for easy access and service. Access panels now include “captive” screws.

D. CABINET: Floor models shall be provided with bar grille louver supply, front toe space return and a 1" high dust barrier at the bottom. Top of unit shall be slope style. All models shall have 18-gauge steel cabinet with 16 gauge front panels. All painted surfaces shall be treated with a process which retards corrosion and promotes paint adhesion and finished with a fan, baked on enamel finish, which may be used as a final coat or repainted. All painted steel shall be galvanized. Color selection shall be by Owner and Engineer.

E. Wall models shall have cabinets with bar grille louvers. The entire bottom of the unit must be enclosed. Access to the speed control shall be through the easy access 16-gauge front/top panels.

F. All models shall have two 9" minimum wide piping end pockets. All wall and ceiling units shall have safety hinged access panels that can be easily removed during installation.

G. MOTORS: Standard motors are 120V, variable speed, ECM type with internal thermal overload protection and are mounted with rubber bushings. Blower wheels are centrifugal, forward curved, and dynamically balanced.

H. COILS: Coils have 3/8" O.D. copper tubing expanded to high efficiency aluminum fins. Each coil is factory tested to 350 psig. Manual air vents are standard on all coils. Tube connections are 5/8" O.D. Left and right hand coil connections are available. DX coils where scheduled

I. DRAIN PANS: All drain pans shall constructed of polymer and be coated on the inside surface with a closed cell, fire retardant foam insulation. This insulation shall be UL Listed and provide superior corrosion resistance. All drain pans include both primary and secondary (overflow) drain connections. All drain pans are sloped toward drain connections to facilitate condensate removal.

J. STANDARD FEATURES: Fans coils shall come completely factory assembled with 2 pipe arrangement.

K. APPROVALS: All standard models shall be UL Listed.

L. VALVE & CONTROL PACKAGE: Ducted fan coil units shall have field installed controls furnished and installed by EMS. Cabinet console style fan coil units shall come with a valve package that shall be fully coordinated with the control vendor to match the control manufacturer for the project. If controls are to be sent from the factory matching the projects control vendor, each unit shall come with a factory piping valve and control package If HVAC Trade contractor elects for factory provided option in lieu of field provided, piping package shall include (2) full port ball style isolation valves, (1) balancing circuit setter valve, (1) strainer, (1) 2-way modulating control valve (3-way where noted on drawings), (1) air vent. Each vertical cabinet style fan coil unit and unit ventilator shall include a factory mounted temperature controller matching project control vendors and unit mounted tamper resistant adjustable controls. Ducted fan coil units and air handlers shall come with factory controls and valves for field mounting, piping and wiring. Control valve pressure drop shall not exceed 3 psi at maximum scheduled design flow.

M. Each unit shall be provided with a chilled/hot water coil, (DX coil if scheduled), filter rack with 1" MERV 8 disposable filters on console style units and MERV 13 on ducted style units and condensate pan with drain, and ECM motor. ECM motor shall include integral speed adjustment on console style units and remote signal EMS control for ducted units. Provide

two (2) spare sets of filters for each unit in addition to those used during start-up and building flush-out.

2.35 HEAT EXCHANGER

A. General

1. Furnish as shown on the plans, a plate & frame style water to water/glycol heat exchanger as manufactured by Alfa Laval, Taco or Bell & Gossett.
2. The heat exchanger manufacturer shall have an established and on-going QA/QC program including manuals available for inspection at plant.
3. The heat exchanger manufacturer shall have extensive background and experience in the design and fabrication of shell & tube style heat exchangers. The manufacturer shall have fabricated shell & tube style heat exchangers for a minimum of twenty (20) years.
4. Heat exchanger shall have 150 psig ASME rated carbon steel shell and #304 stainless steel plates fully serviceable via a removable end.

B. REFERENCES

-ASME Section II - Material Specification
-ASME Section V - Non-Destructive Testing
-ASME Section IX - Welding and Brazing qualifications
-ASME Section VIII - Pressure Vessel Code
-ARI Standard 400 – Liquid to Liquid Heat Exchangers

C. CERTIFICATION

1. ARI Certification
Plate heat exchangers shall be certified according to ARI Standard 400 and listed on the ARI Prime Net site (www.ariprimenet.org). If heat exchanger is not ARI certified, then the manufacturer shall provide an independent third party field performance test using the mapped ratings, limits and tolerances of ARI Standard 400 to verify performance to specification. Any and all cost associated with correcting a non-performing heat exchanger to meet the performance requirements shall be the responsibility of the supplier. Any cost associated with the field performance test shall be included in the price of the heat exchanger.

2. ASME Certification. Heat exchangers shall be designed, constructed, and tested in accordance with Section VIII, Division I of the ASME Pressure Vessel Code, and shall be code stamped.

D. WARRANTY

1. The warranty period shall be 3 years from date of shipment but no less than 1 year from substantial completion.

2.36 FINNED RADIATION

A. Furnish and install, where shown on the Drawings, Slant/Fin Vulcan, Rittling, or Sterling Radiator Co. to be equal to Slant/Fin styles specified below.

B. Enclosures shall be of 14 gauge in cold-rolled steel and shall be furnished with a baked enamel finish, with color selected by the Architect. All baseboard cover in restrooms locker rooms, shower areas and kitchen area shall be constructed of 14 gauge stainless steel.

C. Fin element shall consist of copper tube with aluminum fins of the number of tiers scheduled on the plans.

D. Support brackets shall be die-formed for rigidity and must be designed to support the elements, piping, and enclosures. Slide cradles shall be provided for movement of elements and piping during expansion and contraction. Supporting brackets with slide cradles shall be furnished and installed at a maximum of 3 ft. 0 in. on centers. Provide brackets for return pipe. Pedestal type baseboard shall come with support feet with matching finish.

E. Provide end covers/caps, access panels, inside/outside corners, columns, splice plates, and trim pieces at each wall as required. Provide accessible valve box at each control valve.

2.37 ACCESS PANELS

A. Furnish and install access panels for access to all parts of the HVAC systems that require accessibility for the proper operation and maintenance of the system.

B. Size shall be sufficient for the purpose, but no less than 12 inches by 18 inches. Particular attention shall be exercised in the selection of doors for masonry walls in order that frame sizes used will match the courses of brick or block. Refer to section 08 31 00 for products.

C. Access doors shall be prime coated of rust inhibitive paint, continuous hinge and manufactured by Inland Steel Products Company “Milcor”, Acudor, Mifab, Miami-Carey or Walsh-Hannon-Galdwin, Incorporated “Way Loctor”. Type shall be based upon “Milcor” as follows:

1. Suspended Drywall Ceilings: Style ATR with 16 gauge frame, 18 gauge panel and flush screwdriver operated cam locks.

2. Plastered Walls and Ceilings: Style K with 16 gauge frame, 14 gauge panel and flush screwdriver operated cam locks.

3. Masonry Non-Rated Walls: Style M with 16 gauge frame, 14 gauge panel and flush screwdriver operated cam locks.

4. Masonry Non-Rated Wall: Fire rated with UL 1-1/2 hour “B” rating, 16 gauge frame, 20 gauge sandwich type insulated panel, self-latching lock having interior release mechanism, and key operated cylinder lock keyed as required to suit requirements of the Architect.

5. Non-Rated Dry Walls: Style DW with 16 gauge frame, 14 gauge panel screwdriver operated cam locks.

2.38 THERMOMETERS AND PRESSURE GUAGES

A. Straight Thermometers:

1. Where indicated on the Drawings, furnish and install 7 in. long die-cast aluminum case, "Adjustable Angle" red appearing mercury tubing thermometers, H.O. Trerice Co., Cat. A001 complete with separable stainless steel Type 304 socket, 30 degrees to 240 degrees F. range, and lagging extensions when installed in insulated pipe.

2. Thermometers to be adjusted to a position for maximum readability from normal operator's position.

3. Thermometers shall be H.O. Trerice Co., Weksler Instruments Corp., Weiss Instruments, or approved equal.

B. Pressure Gauges: Pressure gauges shall be as manufactured by Terice, or approved equal, Series 600, 4-1/2 in. diameter, range 0 to 100 PSI (or other range as required by application), aluminum case, white face with black figures, with petcocks. Provide fluid filled gauges at pumps.

C. Provide separable stainless steel wells for each thermometer and pressure gauge. Wells for thermometers shall be filled with heat conductive gel prior to installation of thermometer.

2.39 AIR-COOLED HEAT RECOVERY CHILLER-HEATER

A. Provide microprocessor controlled, air-cooled liquid chiller utilizing HFC-410A. Unit shall be rated in accordance with ARI Standard 550/590, latest revision (U.S.A. under 200 tons). Unit construction shall comply with ASHRAE 15 Safety Code, NEC, and ASME applicable codes (U.S.A. codes). Unit shall be manufactured in a facility registered to ISO 9002/BS5750, Part 2 Manufacturing Quality Standard. Unit shall be full load run tested at the factory. Unit shall be modular in design with multiple 30-ton modules combined to support a nominal 180-tons of cooling (150-tons in simultaneous cool/heat mode) with associated heating. Unit shall have a duplex style primary pump packages for both the chilled and hot water side. Manufacturers shall be Multi-Stack model ARA or approved equal.

B. Factory assembled; modular air-cooled liquid chiller. Contained within the unit cabinet shall be all factory wiring, piping, controls, refrigerant charge (HFC-410A), and special features required prior to field start-up.

C. Provide chiller with integral all accessories and options indicated on the schedules and specified herein.

D. Chiller shall be capable of generating either hot water, chilled water or both hot and chilled water simultaneously. Chiller-heater shall be capable of generating hot water up to 130°F at 0°F ambient.

E. General

1. Provide outdoor packaged air-cooled liquid heat pump heat recovery chiller with the Hot water and Chilled Water capacities as scheduled on drawings at job site elevation listed in Section 15050. Non modular chiller designs shall not be acceptable.

2. Basis of design is Multistack or approved equal.

3. Chiller shall be designed to operate using R-410A Refrigerant.

4. Five (5) year compressor warranty from date of startup must be provided by the chiller manufacturer.

5. Chiller/Heater Modules shall be ETL listed in accordance with UL Standard 1995, CSA certified per Standard C22.2#236. Prior to shipment the chiller controls shall be tested under power to verify proper controls operation.

6. Unit shall be stored and handled in accordance with manufacturer's instructions.

7. Unit shall be shipped with all refrigerant piping and control wiring factory installed.

8. Each Chiller shall have:

   a) A single power connection to support 5 of the 6 modules with a separate power connection to support one module on emergency power.
   b) A single hot water supply connection.
   c) A single hot water return connection.
   d) A single chilled water supply connection.
   e) A single chilled water return connection.
   f) A single point for all BAS control connections (ensure this is on the module with the emergency power supply).
   g) Evaporator and condenser insulation.
   h) A separate pump package include chilled and hot water pumps, starters, disconnects and controls. Unit shall be have controls field wired to the main chiller controller.

9. Unit shall be shipped pre-charged with refrigerant and oil as specified on the equipment schedule.

10. Chiller shall be designed for parallel water flow through both the chilled water and hot water piping supplies to each module. The liquid to be chilled/heated will be water containing corrosion inhibitors and antifreeze solution as required.

11. Unit shall be shipped with firmly attached metal plates that indicate name of manufacturer, chiller model number, chiller serial number, and refrigerant used.

12. The chiller shall be selected to meet or exceed performance requirements as indicated in drawings.

13. Compressors, heat exchangers, condenser fans, piping and controls shall be mounted on a heavy gauge, powder coated steel frame. Electrical controls, contactors, and relays for each module shall be mounted within that module. Module shall be provided within a steel enclosure suitable for outdoor use. Exposed steel surfaces shall be provided with a powder coat paint finish.

B WATER TO WATER LOW AMBIENT HEAT PUMP CHILLER

1. Water to water low ambient heat pump chiller with auxiliary air cooled condenser shall incorporate Scroll type compressors and can consist of multiple 30-ton modules. Each refrigerant circuit shall consist of a tandem compressor set, evaporator, refrigerant to hot water heat exchanger, air to refrigerant heat exchanger, electronic expansion valves, liquid line solenoid valves, filter driers, (4) 2-way motorized refrigerant valves, and control system. Each circuit shall be constructed to be independent of other circuits from a refrigeration and electrical stand-point. The multi-module chiller must be able to produce chilled water and hot water even in the event of a failure of one or more refrigerant circuits.

2. Load Water Mains:

   1) Chilled Water Mains: Each module shall include supply and return mains for chilled water. Cut grooved end connections are provided for interconnection to four, six, eight-inch standard piping with grooved type couplings – unless otherwise specified on the schedule. Rolled grooved shall be unacceptable.

   2) Hot Water Mains: Each module shall include supply and return mains for hot water. Cut grooved end connections are provided for interconnection to four, six, eight-inch standard piping with grooved type couplings – unless otherwise specified on the schedule. Rolled grooved shall be unacceptable.

3. Source/Sink Fans: Each module shall contain two fans. Module shall utilize ECM Fans. Blades are aluminum construction owlet design 7-blade axial fan with integral EC motor (direct drives with external VFD driven motors are not acceptable). Efficiency exceeds criteria set out in the ErP 2015 directive. Individual fans are factory tested. Encapsulation required. Encapsulation is a process of filling a complete electronic assembly with a solid compound for resistance to shock and vibration, and for exclusion of moisture and corrosive agents. Sound pressure reductions at 30 feet, as compared to standard fan option, ranges from 3-6 dBA.

4. Compressor: Each module shall contain two scroll compressors with refrigerant injection technology. The compressors have active map management to monitor discharge temperature, resulting in safe compressor operation and maximizing lift capabilities. Compressors are in a tandem piping arrangement mounted to the module with rubber-in-shear isolators. Each system also includes high discharge pressure and low suction pressure safety cut-outs. Compressors must be designed specifically to produce 130 deg F hot water at 0 deg F ambient in air source heat pump/heat recovery chiller/heater.

5. Refrigerant to Water Heat Exchangers

1) Evaporator: Each evaporator shall be a brazed plate heat exchanger constructed of 316 stainless steel; designed, tested, and stamped in accordance with UL 1995 code for 650 psig working pressure. The evaporator heat exchanger shall not be mounted above the compressor, to eliminate the effect of migration of refrigerant to the cold evaporator with consequent liquid slugging on start-up.
2) Condenser: Each condenser shall be a brazed plate heat exchanger constructed of 316 stainless steel; designed, tested, and stamped in accordance with UL 1995 code for 650 psig working pressure.

6. Chiller/heater shall have external inputs and outputs to be compatible with the building management system to include Remote Start/Stop capability and Cooling Alarm output.

7. Each refrigerant circuit shall include all refrigerant specialties including a properly sized refrigerant receiver to provide reliable operation down to 0°F Ambient. Chiller must be able to reliably produce 130 deg F hot water at 0 degrees F Ambient.

8. Heat Pump shall be provided with a single point power connection at a 65,000 amp SCCR. This will include pre-engineered wiring for field installation and connection to a factory mounted Heat Pump junction box. Junction box shall include individual fusing for each Module Set and provide a single point of connection to building power. Chillers with MCA over 500 Amps shall be provided with dual point power.

9. Heat Pump Chiller shall ship from the factory on a six (W6X15) inch I-beam painted steel frame will be provided with all modules mounted upon it. Typically, all water and wiring connections will be made between the modules at the factory. Depending on chiller length or customer requests, larger I-beams can be furnished.

10. IFM flow switch per module. Integral to each module and powered by the module for individual module proof of flow and flow safety. Modules without independent IFM switches per module are not acceptable alternates.

11. All wiring, including communication wiring from the master controller must be factory installed. Each heat pump chiller skid must be controlled by a single master controller able to oversee the operation of the chiller skid. If the chiller does not have a modular design with a master controller able to be factory wired, the manufacturer must provide a full plant controller system separate from the BMS capable of controlling all heating and cooling operation. If the manufacturer does not provide a plant controller to control flow and chiller mode operation of a non-modular design, the ATC/contractor is responsible for providing the chiller/heater plant controller in addition to their base scope.

12. Variable Flow Operation: Chilled Water and Condenser Water Butterfly type isolation valves shall incorporate appropriate accessories and controls to allow the chiller to operate efficiently in a variable primary flow system. Motorized valve per module shall operate for variable flow. Chiller system must be able to turn down to a single modules flow. Chiller must be capable of variable flow via factory controls and a single set up pumps. If the chiller is not capable, the manufacturer or installing contractor must provide a hot water and chilled water plant controller system and all associated valves, pumps and piping accessories needed to accomplish variable flow.

13. Sound Attenuation Package: Chiller must meet the sound levels shown on the schedule. ECM fans must be included for control and sound attenuation.

14. Flow switches: Manufacturer shall factory install flow switches on chillers shipped with lifting frames.

15. Pump Module – Hot Water and Chilled Water

    1) Provide a Pump Module of size and capacity indicated on the drawings and schedules. Pump Module will be an integral part of the chiller system. Pump Module shall incorporate Dual-Arm chilled water and Dual-Arm hot water in-line centrifugal pumps in a Primary/Standby pumping arrangement. Pump starters and controls shall be provided to enable manual selection of lead pump. In addition, in the event of a loss-of-flow failure of the chilled water system, the Pump Module controls shall disable the lead pump and automatically start the standby pump. Module shall be completely factory assembled and tested prior to shipment.

    2) VARIABLE FLOW VFD's

        a) VFD shall be provided per pump to allow for variable flow.

    3) Chilled water pumps shall include the following:

        a) Auto lead/lag timer – Evap

        b) Suction and Discharge Water Pressure Gauges (4" Glass Lens) – Evap

        c) Pump suction and discharge pressure taps – Evap

        d) One thermal dispersion flow switch for Primary/Standby pump switchover-Evap

        e) Integral Isolation/check valve for servicing one pump while the standby is operational – Evap

    4) Hot water pumps shall include the following:

        a) Auto lead/lag timer – Cond

        b) Suction and Discharge Water Pressure Gauges (4" Glass Lens) - Cond

        c) Pump suction and discharge pressure taps - Cond

        d) One thermal dispersion flow switch for Primary/Standby pump switchover-Cond

        e) Integral Isolation/check valve for servicing one pump while the standby is operational - Cond

C CONTROLS, SAFETIES AND DIAGNOSTICS

1. Scheduling of the various compressors shall be performed by a microprocessor-based control system (Master Controller). A new lead compressor is selected every 24 hours to assure even distribution of compressor run time.

2. The Master Controller shall monitor and report the following on each refrigeration system:

   a. Discharge Pressure Fault

   b. Suction Pressure Fault

   c. Compressor Winding Temperature

   d. Suction Temperature

   e. Evaporator Leaving Chilled Water Temp.

   f. Condenser Leaving Hot Water Temp.

3. The Master Controller shall monitor and report the following system parameters:

   a. Chilled Water Entering and Leaving Temperature

   b. Discharge/Suction Refrigerant Temperature

   c. Proof of Chilled Water Flow

   d. Hot Water Entering and Leaving Temperature

   e. Discharge Refrigerant Temperature

   f. Proof of Hot Water Flow

4. An out of tolerance indication from these controls or sensors shall cause a “fault” indication at the Master Controller and shutdown of that compressor with the transfer of load requirements to the next available compressor. In the case of a System Fault the entire Heat Pump will be shut down. When a fault occurs, the Master Controller shall record conditions at the time of the fault and store the data for recall. This information shall be capable of being recalled through the keypad of the Master Controller and displayed on the Master Controller’s LCD. A history of faults shall be maintained including date and time of day of each fault (up to the last 20 occurrences).

5. Individual monitoring of leaving Load water temperatures from each refrigeration system shall be programmed to protect against freeze-up. Individual monitoring of leaving hot water temperatures from each refrigeration system shall be programmed to protect against hi head pressure conditions.

6. The Chiller shall be capable of interfacing to a building automation system. Interface shall be accomplished using an Interoperability Web Portal and shall be capable of communication over BACNet IP or MSTP, Modbus or LON.

7. Operation

   a. The control system shall monitor entering and leaving chilled water and hot water temperatures to determine both the chilled water and hot water system demand. The control system will use the demand to make staging mode (cooling, heating, or simultaneous heat recovery) decisions and select the number of compressor circuits required to operate. Mode decisions shall be available from the controller as well as via remote input. Response times and set points shall be adjustable. The system shall provide for variable time between compressor sequencing and temperature sensing, so as to optimize the chiller performance to different existing building loads.

   b. Modules shall be able to provide the following capabilities:

      1) Full cooling capacity with zero need for hot water

      2) Full simultaneous heat recovery, providing full heating and cooling capacities.

      3) Full heating capacity with zero need for chilled water.

8. The chiller safety controls shall be provided (minimum) as follows:

   a. Low evaporator refrigerant pressure

   b. Loss of water flow through the evaporator

   c. High condenser refrigerant pressure

   d. High compressor motor temperature

   e. Low suction gas temperature

   f. Low leaving evaporator water temperature

9. Failure of chiller to start or chiller shutdown due to any of the above safety cutouts shall be annunciated by display of the appropriate diagnostic description at the unit control panel. This annunciation will be in plain English. Alphanumeric codes shall be unacceptable.

10. The chiller shall be furnished with a Master Controller as an integral portion of the chiller control circuitry to provide the following functions:

    a. Provide automatic chiller shutdown during periods when the load level decreases below the normal operating requirements of the chiller. Upon an increase in load, the chiller shall automatically restart.

    b. Provisions for connection to automatically enable the chiller from a remote energy management system.

    c. The control panel shall provide alphanumeric display showing all system parameters in the English language with numeric data in English units.

11. Normal Chiller Operation

    a. When chiller is enabled, the factory supplied Master Controller modulates the chiller capacity from minimum to maximum as required by building load.

    b. The Chiller control system shall respond to Entering Water Temperature and will have an integral reset based on entering water temperature to provide for efficient operation at part-load conditions.

12. Provide BACnet interface card(s) for full communication to the building EMS for remote monitoring and mode and setpoint adjustment.

D. ELECTRICAL REQUIREMENTS

1. It shall be the responsibility of the HVAC Contractor to furnish the Electrical and ATC Contractor with all wiring requirements to be performed as specified hereinafter.

2. Electrical contractor shall supply and install main electrical power line, disconnect switches, circuit breakers, electrical protection devices per local code requirements and indicated necessary by the chiller manufacturer.

3. ATC Contractor shall wire the water flow switches to the chiller control circuit to ensure that chiller will not operate until flows are established and maintained.

4. ATC Contractor shall supply and install electrical wiring and devices required to interface the chiller controls with the building control system.

5. Electrical power shall be supplied to the unit by the Electrical Contractor at the voltage, phase and frequency listed in the equipment schedule.

6. A single power connection shall be supplied to support 5 of the 6 modules with a separate power connection to support one module on emergency power.

E. PIPING REQUIREMENTS - INSTRUMENTATION AND SAFETIES

1. The HVAC Contractor shall supply and install pressure gauges in readily accessible locations in piping adjacent to the chiller such that they can be easily read from a standing position on the floor. Gauges shall be Marsh Master or equal with 4 1/2" nominal diameter face. Scale range shall be such that design values shall be indicated at approximately mid-scale.

2. Gauges shall be installed in the leaving water piping of the chiller skid.

3. The HVAC Contractor shall install flow detection devices in chilled water and condenser water piping. Switches shall be differential type. Switches shall be installed in horizontal runs at least (5) pipe diameters downstream from any bend or tee.

F. INSTALLATION

1. In accordance with manufactures written instructions and recommendations.

2. Coordinate location and all required clearances and code clearances required.

3. Coordinate and provide all interlock wiring.

4. Provide a factory-trained representative, employed by the chiller manufacturer, to perform the start-up procedures as outlined in the start-up, operation and maintenance manual provided by the chiller manufacturer.

5. Provide classroom instruction for a minimum of (8) hours to instruct the Owner's personnel in the proper operation and maintenance of the chiller.

6. The HVAC Contractor shall supply the Owner with the following literature as furnished by the manufacturer prior to start-up:

    a. One (1) complete set of installation drawings
    b. Field wiring diagrams
    c. Installation instructions
    d. Start-up, operation and maintenance instructions

7. Piping System Flushing Procedure

    a. Prior to connecting the Heat Pump to the building Load water loop, the piping shall be flushed with a detergent and hot water (110-130° F) mixture to remove previously accumulated dirt and other organic residue. In old piping systems with heavy encrustation of inorganic materials consult a water treatment specialist for proper passivation and/or removal of these contaminants.

    b. During the flushing a 30 mesh (max.) Y-strainers (or acceptable equivalent) shall be in place in the system piping and examined periodically as necessary to remove collected residue. The use of on board chiller strainers shall not be acceptable. The flushing process shall take no less than 6 hours or until the strainers, when examined after each flushing, are clean. Old systems with heavy encrustation shall be flushed for a minimum of 24 hours and may take as long as 48 hours before the filters run clean. Detergent and acid concentrations shall be used in strict accordance with the respective chemical manufacturer’s instructions. After flushing with the detergent and/or dilute acid concentrations the system loop shall be purged with clean water for at least one hour to ensure that all residual cleaning chemicals have been flushed out.

    c. Prior to supplying water to the Heat Pump the Water Treatment Specification shall be consulted for requirements regarding the water quality during Heat Pump operation. The appropriate Heat Pump manufacturer’s service literature shall be available to the operator and/or service contractor and consulted for guidelines concerning preventative maintenance and off-season shutdown procedures.

8. Water Treatment Requirements

a. Supply water for the Load water circuit shall be analyzed and treated by a professional water treatment specialist who is familiar with the operating conditions and materials of construction specified for the Heat Pump's heat exchangers, headers and associated piping. Cycles of concentration shall be controlled such that recirculated water quality for modular Heat Pumps using 316 stainless steel brazed plate heat exchangers and carbon steel headers is maintained within the following parameters: Both the chilled and hot water sides shall be

1)	pH	Greater than 7 and less than 9
2)	Total Dissolved Solids (TDS)	Less than 1000 ppm
3)	Hardness as CaCO3	30 to 500 ppm
4)	Alkalinity as Ca CO3	30 to 500 ppm
5)	Chlorides	Less than 200 ppm
6)	Sulfates	Less than 200 ppm

G. INSTALLATION

1. Start-Up Service: The manufacturer shall furnish a factory trained service technician without additional charge for a minimum of two days.

2. Owner Training: Manufacturer shall provide instruction of the Owner's personnel on the operation and maintenance of the unit.

3. Warranty: Warranty shall include all inspections, troubleshooting and all parts and the labor to install faulty parts. Refrigerant shall also be included and the labor to add refrigerant to the system.

4. Commissioning Assistance: The manufacturer shall furnish a factory trained service technician without additional charge for a minimum of two days (16 hours) to assist with commissioning after startup has been performed.

2.40 WATER THERMAL BUFFER TANKS

A. The chilled water and hot water thermal buffer tanks shall be Cemline model #V500CWB-F-SL-15-I, 500-gallon factory insulated and jacketed vertical tanks or equal by Lochinvar, AO Smith or Wessels. The steel tank shall have a seismic rated base stand with anchor mounts. The tank shall include an internal baffle. The tank shall be ASME constructed and designed for 125 PSI working pressure and equipped with a hand-hole for cleaning and inspection and have red oxide pain coating. The tank shall be insulated with R-12 closed cell foam insulation that completely surrounds the tank. The tank insulation is high density foam insulation and shall meet or exceed ASHRAE Standard 90.1. Tanks shall be ASME bearing the ASME Sec. VIII U Stamp and rated for 125 PSI working pressure. The tank shall be covered by a five (5) year limited warranty against leaks.

B. Provide top mounted automatic air vent taping with high capacity air vent and temperature/pressure relief valve. In addition, provide a 1" drain tapping with filed provided ball valve with hose bib connection, cap & chain.

C. Provide upper connections with two (2) 6" flanged tappings.

2.41 COMPUTER ROOM AC UNITS

A. This specification describes requirements for a precision environmental control system. The CyberOne floor-mounted air conditioning system manufactured by Stulz provides precision temperature and/or humidity control for computer rooms or rooms containing communications or other highly sensitive heat load equipment where continuous 24-hour, 365-days a year air conditioning is required. The units are designed with a wide range of options to handle all precision cooling applications. Or equals shall be by Leibert or APC may be considered.

B. Up-Flow Cabinet: Access panels are fabricated from 14 gauge galvannealed steel. Door jambs are fabricated from 16 gauge galvannealed steel. Top and bottom cabinet frame is fabricated from 10 gauge galvannealed steel. The panels are lined with 1/2 inch (13 mm), 2 lb (.90 kg), high-density sound and thermal insulation and sealed with a self-extinguishing gasket conforming to NFPA 90A and 90B. The standard unit color is black, extra fine texture. A white finish shall optionally be provided.

C. The condenser cabinet shall be constructed of 0.090 inch aluminum and shall be securely fastened to a frame constructed of 0.125 inch aluminum. The condenser cabinet shall house the condenser coil, fan(s), fan guard(s), condenser motor control and NEMA 3R electric box. The receiver will be mounted on cabinet frame and come pre-piped when required. Unit shall use R-407C or R410A refrigerant and once installed be fully charged for operation. Unit shall have a receiver and controls for stable operation down to -10F outdoor ambient.

D. All units are supplied with disposable air filters classified as UL 900 or UL 586. Filters are 2 inches deep (nominal). Filters are pleated with a Minimum Efficiency Reporting Value (MERV) of 8. Filters are installed in a front accessible, steel holding frame, and are accessible through the front of the unit (except for the rear return configuration). Optional: Filters rated up to MERV 11 are available.

E. Fans shall be EC type with variable speed control.

F. The humidifier is a self-contained atmospheric steam generator. The humidifier assembly shall include an integral fill cup, fill and drain valves, disposable steam cylinder and associated piping. The humidifier is equipped with an auto adaptive control system to optimize water conductivity, control automatic drain/flush cycles, minimize energy waste and maximize cylinder life. The humidifier has a modulating output between 20% and 100% of the rated capacity. The unit shall include draw in water tempering to ensure the drain water does not exceed 140°F during operation.

G. The system is provided with a dehumidification control mode. The chilled water valve is opened to allow chilled water flow when a dehumidification demand exists. Moisture is condensed on the cooling coil and discharged through the condensate drain. Reheat (electric) is provided to offset sensible cooling during the dehumidification cycle. If chilled water is not available or not adequate to achieve dehumidification (water too warm), the unit shall dehumidify using DX coil.

H. A factory mounted and wired low-watt density, plated fin-tubular design electric resistance heater is included to provide automatic sensible reheating as required during the dehumidification cycle and automatic heating mode. Electric heaters are provided with miniature thermal/magnetic circuit breakers, which shall protect each ungrounded conductor. Also included will be one automatic reset and one manual reset over-temperature safety device (pilot duty). Heaters shall have modulating SCR control.

I. The electrical system shall conform to National Electrical Code requirements. The control circuit is 24 volts AC, wire in accordance with NEC Class II requirements. The control circuit wire shall not be smaller than 18 AWG. All wiring is neatly wrapped and routed in bundles. Each wire shall end with a service loop and be securely fastened by an approved method. Each wire in the unit is numbered for ease of service tracing. All electrically actuated components are easily accessible from the front of the unit without reaching over exposed high voltage components or rotating parts. Each high voltage circuit is individually protected by circuit breakers or manual motor starters on all three phases. The blower motor has thermal and short circuit protection. Line voltage and 24-volt control circuit wiring is routed in separate bundles. The electric box is positioned for service convenience and shall include all the contactors, starters, fuses, circuit breakers, terminal boards and control transformer required for operation of the unit and shall allow for full service access.

J. The advanced microprocessor-based controller is equipped with flexible software capable of meeting the specific needs of the application. The setpoints are default and their ranges are easily viewed and adjusted from the user interface display. The program and operating parameters are permanently stored on a non-volatile system in the event of power failure. The controller is designed to manage temperature and relative humidity (RH) levels to a user defined setpoint via control output signals to the system. Control parameters have variable outputs from 0 to 100% of the full rated capacity. The controller shall receive inputs for measurable control conditions (temperature, relative humidity, and dew point) via return air or room mounted sensors. The internal logic will then determine if the conditions require cooling, humidification or dehumidification. Control setpoints are established to maintain design conditions of the installation. The controller will respond accordingly to changes in these conditions and control the output/demand for the appropriate mode of operation until user defined conditions are achieved. The E² series controller shall incorporate a communication interface port that can be field connected to a Building Management System via Modbus, BACnet MS/TP, SNMP, HTTP, or BACnet over ETHERNET/IP as configured by the factory. A controller interfaced to a network must be configured for BMS communication.

K. The large bezel touch screen user interface display panel features a high-resolution backlit liquid-crystal graphical display equipped with contrast adjustment and LED illuminated function keys. The screens that appear on the user interface display panel present data that is from the controller.

L. An adjustable floor stand shall be provided to allow for ease of installation of the CyberOne EC floor- mounted air conditioning system onto a raised floor environment. Floor stand height is adjustable ship separately for field installation.

M. A condensate pump is factory installed within the CyberOne EC floor-mounted air conditioning system for automatic removal of condensate and humidifier flush water (if applicable). The condensate pump shall include an internal overflow safety float switch, when wired to the remote start/stop terminals, shall open the control circuit, thereby shutting the unit down in the event of a condensate overflow. The condensate pump is specifically

designed to operate with the higher condensate temperatures caused by the flush and drain cycle of the electrode canister humidifiers.

N. A photo-electric smoke detector is factory installed and wired in the return air section of the CyberOne EC floor-mounted air conditioning system. The photo-electric detector shall include built-in circuitry that performs a functional test of all detection circuits at least once every 40 seconds without the need for generating smoke. The UL listed velocity range is 0-3000 fpm. The air conditioner will shut down upon sensing smoke in the return air stream.

O. The CyberOne EC floor-mounted air conditioning system is provided with a factory wired and mounted firestat. The firestat will shut down the air conditioner upon sensing a high return air temperature.

P. A 20 foot remote strip/cable type water/leak detector is provided for remote field installation. In addition to the 20 ft. sensing cable, a 24-volt water detector power module requires field mounting and wiring to the factory provided terminal connection. Upon sensing a water leak, the normally closed water detector control circuit shall open, thereby shutting down the CyberOne floor- mounted air conditioning unitwater producing components.

Q. Units shall be configured for ducting to the cold aisles as shown on the plans.

R. The supplied system is with the following compliance approvals: C ETL US listed to UL 1995 (2011 Ed. 4), CSA C22.2 No. 236 (2011 Ed. 4). Provide power disconnect switches for indoor units and exterior condensers.

2.42 LOUVERS

A. Louvers meeting the following specifications shall be furnished and installed where shown on the plans. Louvers shall be stationary type with drainable blades in a 4” louver frame. Each stationary blade shall incorporate an integral drain gutter and each jamb shall incorporate an integral downspout so water drains to blade end, then down the downspouts and out at the louver sill rather than cascading from blade to blade.

B. Each factory-assembled louver section shall be designed to withstand wind loadings of 25 pounds per square foot (100 mph wind equivalent). Louver frames, mullions, and section joints shall be adequately supported from the building structure to withstand this same wind loading.

C. Louver performance data shall be licensed under the AMCA Certified Ratings Program and shall bear the AMCA Certified Ratings Seal. This certified performance data shall include airflow pressure loss and water penetration, and shall demonstrate performance equal to or better than the Greenheck model specified.

D. Louvers shall be Greenheck model #ESD-403 drainable type fabricated from 60637T5 aluminum extrusions of 0.081” nominal wall thickness. Blades shall be positioned at 37° and 45°angles approximately on 4” centers. Each louver shall be equipped with a framed, removable, rear-mounted screen of ¾” x 0.051” expanded flattened aluminum.

A. Louver shall be supplied with a Kynar finish applied following a thorough cleaning and pretreatment of the metal surface. Dry film thickness of the Kynar shall be approximately 1.2 mils after baking at 450°F. Custom color shall be selected by the architect and shall include metallic color options. Submit color chart.

F. All louvers shall include bird screens. Insect screens shall be required only on intake louvers that serve air make-up directly into a space without going thru an air filter and must include access panels in duct sleeves to allow for cleaning of screens.

G. Manufacturers shall be Greenheck, Ruskin or Airolite

2.43 DUCT AND UNIT MOUNTED AIR IONIZERS

A. For RTU-1, 2, 3, & 4 provide supply plenum unit mounted tube style bi-polar air purifier ionization systems as scheduled by AtmosAir or approved equal by Bioclimatic Air Systems or Bio-Oxygen America. Ionizers shall be mounted within the respective RTU unit supply air plenum and/or supply fan chamber. For RTU & AHU systems up to 2,000 CFM provide (1) #M1000 unit, for system from 2001 CFM to 5,000 CFM provide (1) #M1002 unit, for systems from 5001 CFM up to 9,000 CFM provide one (1) #500EC unit. Units shall have plenum rated power supply and BAS alarm contact. For airflows above these provide multiples of the above models based on the system supply airflow.

B. For all other RTU's (other than 1 thru 4) provide needlepoint bipolar air purifier ionization systems as described herein by Global Plasma Solutions (GPS) model #GPS-FC48-AC auto cleaning ionizer or equal. Unit shall have screw and magnet mounting options, replaceable carbon brush emitters, programmable auto-cleaning rotating sweep, plenum rated power supply and BAS alarm contact. For RTU & AHU systems up to 4,800 CFM provide one unit. For airflows above 4,800 CFM provide multiples of the above model based on the system supply airflow.

C. Units shall be installed per manufacturers instruction and contractor must coordinate final mounting location and mounting method with both the ionization manufacturer and RTU manufacturer.

D. Units shall be plenum rated and UL 1995, 867 & 2043 listed and Energy Star certified. Units shall come with wiring for external connection to a 120 volt power supply, provide single pole disconnect switch. Tube style units shall include an adjustable knob for 5 levels of ion generation and be constructed of Mono-Core composite and stainless steel.

E. Each bi-polar ionization air purifier shall be capable of effectively reducing and/or agglomerating microorganisms throughout the ductwork and interior occupied spaces served by the bipolar system (including mold, bacteria, vapors, viruses and other airborne particulates), controlling gas-phase contaminants including Volatile Organic Compounds (VOC's) generated from human occupants, building structure and furnishings, and reducing static space charges.

F. Laboratory Testing Performance. Each bi-polar ionization manufacturer must have third party laboratory testing results proving contaminant reductions against MS2, Staph, E. Coli, Dust, Mold, and C. Difficile.

G. Field Performance. The Bi-Polar Ionization system manufacturer shall produce five documented installation references including client contact information with the following criteria: 1) Systems shall have operated continuously for a minimum of 3 years; 2) Installations must be greater than 10,000 CFM serving office or healthcare spaces; 3) Systems shall have a documented ability to reduce volatile organic compound (TVOC levels), particulate (PM) levels, and not increase ozone (O3) in both before and after installation results from air testing completed within the occupied space. Results must

include real-time performance results on Particulate Matter 2.5 (PM2.5), Total Volatile Organic Compounds (TVOC), and ozone (O3).

H. Tube Style Only: Ionization tubes must be constructed from durable, shatterproof material, not glass, and last for 2 years. Tube Quantity. A 21" bi-polar ionization tube must meet certain CFM requirements for different building descriptions: 1) One (1) 21" bi-polar ionization per 1,875 CFM of supply air in Residences, Airports, Office Spaces, Day Care Centers and Schools; 2) One (1) 21" bi-polar ionization tube per 938 CFM of supply air in Nursing Homes, Locker Rooms, Manufacturing, Food Processing, and Restaurants; 3) One (1) 21" bi-polar ionization per 625 CFM of supply air in Beauty Salons, Casinos, Waste Water Applications, Industrial Facilities, Garbage Rooms, Kennels.

I. Manufacturer to provide third party ozone testing from 10 locations where technology is installed. Manufacturer must provide third party proof that there is no measurable increase in ozone levels within the space.

J. Relative humidity from 0% to 99% shall not cause damage, deterioration or dangerous conditions within the purification system.

K. Operation of the electrodes or bi-polar generator unit shall conform to ASHRAE Standard 62 and UL867 with respect to ozone generation.

L. The generator unit shall provide a minimum of 86% reduction of PM0.3 smaller particles. Independent testing performance criteria shall be provided within the submittal.

M. Provide one (1) real time IAQ monitor in the return air duct of each of the RTU's. Unit must measure at a minimum CO2, Temperature, RH, Pm 2.5, and TVOC. Unit shall communicate to the EMS via BACnet.

N. Provide one (1) portable Air Ion Counter model #AIC2 as manufactured by Alpha Lab Inc. or equal along with a USB-DL1 USB data logger converter. Device shall have an LCD display and adjustable range of 0 to 2,000 up to 2,000,000 ions per CC with a resolution of 10 ions per CC

O. Tube Style Only: Each unit shall include the required number of composite tubes sized to the scheduled capacity of the duct and/or air handling unit. The tube shall be installed into a tube base with suitable bonding material and be hermetically sealed to prevent moisture penetration. The tube base shall include an external molded ring, which seals the tube base to the socket which shall be water/moisture proof. Glass tubes are not permitted due to potential of shatter caused by vibration. Needlepoint Ion generators shall not be permitted due to unproven performance, ozone production, corrosion, and maintenance life.

P. The bi-polar ionization system shall operate in a manner such that equal amounts of positive and negative ions are produced. Uni-polar ion devices shall not be acceptable.

Q. The bi-polar ionization system shall be designed to increase ionization levels in the areas served by the handlers, ducts and/or plenums where Bi-Polar Ionization systems are installed. The acceptable ionization level increase in such areas shall be between 500 and 1,500 ions per cubic centimeter as measured by an Alpha Labs air ion counter model AIC 2.

R. The operation of the air purification system shall be through bi-polar ionization utilizing association/disassociation process. It shall operate in such a manner so that agglomeration

or precipitation of airborne particulates shall not be permitted to collect on occupants, walls or furnishings by virtue of its operation.

S. Provide indicator light, mounting brackets and air pressure switch set to automatically shut down unit when airflow is not proved.

T. Units shall include a manufacturer's warranty for 2 years. Warranty includes Ion generation tubes shall maintain at least 90% output for 18,000 hours. Ion tubes shall be replaceable.

U. Provide one complete replacement set of ion tubes for each ionizer.

V. Manufacturer's representative shall provide Owner training on operation, cleaning and maintenance of the units including how tubes are replaced. A minimum of 4 hours shall be provided.

2.44 ELECTRICAL WORK

A. The Heating, Ventilating and Air Conditioning Contractor shall provide all wiring for the Automatic Temperature Controls, air handlers, duct smoke detectors (fan interlock and control loop power), condensers, etc.. except as otherwise specified herein.

B. The HVAC contractor shall hire a licensed electrician to perform all control wiring as required by code. Minimum gauge of all control wiring is 18 AWG and shall be plenum rated.

C. The Electrical Contractor shall install and do all power wiring for all motor starters and unmounted motors, furnished to him at the job site by other trades.

D. For all low voltage motors, temperature control wiring and motor control wiring, including wiring for interlocking, shall be provided by the Section providing the motors, including the installation of all control devices.

E. Furnish all starters and all other motor control devices for motor driven equipment required for the work. The Electrical Contractor shall provide all code required disconnect switches for all motors, except where otherwise noted. The setting of all motors required for mechanical equipment shall be included as part of the mechanical work.

F. Equipment which includes a number of correlated electrical control devices mounted in a single enclosure or on a common base with equipment, shall be supplied for installation completely wired as a unit with terminal boxes and ample leads ready for external wiring.

G. All electrical items called for as part of the mechanical work shall conform to NEMA Standards, to the requirements of the National Fire Protection Association and to the requirements of any local electrical code authority having jurisdiction, any field modifications required to ensure such conformance shall be included as part of the mechanical work.

2.45 ELECTRIC MOTORS

A. This Contractor shall provide all electric motors necessary for driving all motor driven equipment required to be furnished under this section of the Specifications.

B. All motors shall be designed for 3 phase, 60 cycle alternating current operation with 460 volts across the motor terminals, except that, unless otherwise specified herein, all motors

1/3 HP and smaller shall be designed for single phase, 60 cycle alternating current at 120 volts across the terminals.

C. The speed, horsepower, type and other essential data for each motor, if not given under paragraphs describing the various motor driven apparatus, or in schedules on the drawings shall be submitted to the Engineer for his review. All motors shall be premium efficiency type and any connected to a VFD shall have a shaft grounding ring.

D. Contractor shall furnish premium efficient motors eligible for rebate by the local electric utility, when applicable.

2.46 SCAFFOLDS AND STAGING

A. General: Trade Contractors shall obtain required permits for, and provide scaffolds, staging, and other similar raised platforms, required to access their Work as specified in Section 01 50 00 – TEMPORARY FACILITIES AND CONTROLS and herein.

1. Scaffolding and staging required for use by this Trade Contractor pursuant to requirements of Section 01 50 00 – TEMPORARY FACILITIES AND CONTROLS shall be furnished, erected, maintained in a safe condition, and dismantled when no longer required, by this Trade Contract requiring such scaffolding.
2. Each Trade Contractor is responsible to provide, maintain and remove at dismantling, all tarpaulins and similar protective measures necessary to cover scaffolding for inclement weather conditions other than those required to be provided, maintained and removed by the Construction Manager pursuant to MGL (Refer to Section 01 50 00 – TEMPORARY FACILITIES AND CONTROLS and as additionally required for dust control).
    a. Construction Manager is responsible to provide enclosures required for temporary heat from November 1 to March 31; refer to Section 01 50 00 – TEMPORARY FACILITIES AND CONTROLS.
3. Furnishing portable ladders and mobile platforms of all required heights, which may be necessary to perform the work of this trade, are the responsibility of this Trade Contractor.

2.47 RTU ACCESS PLATFORMS

A Provide elevated service platform at RTU-12, 13, 21 & 22 to the extent shown on the drawings but extending no less than 48” out from the service sides of the units as manufactured by PHP, RTS or approved equal. System shall be an engineered prefabricated system designed for installation without roof penetrations, flashing or damage to the roofing material. The system shall consist of bases, made of high density polypropylene plastics with UV Protection, a galvanized structural steel frame, walkway planking, and handrails for full OSHA compliance. Nuts, threaded rods and washers shall be HDG, spring nuts and bolts for spring nuts will be electroplated. System shall be custom designed to fit the load requirements that will be required but in no case less than 500# live load. Access platforms shall be 48” wide (out from RTU). All hoisting equipment, rigging equipment, crane services and lift machinery required for the work by this Trade Contractor shall be furnished, installed, operated and maintained in safe conditions.

B. Elevated platform and stair system shall consist of the following.
1. Bases High Density Polypropylene plastics with additives for UV protection
2. Substructure: 12 gauge back-to-back strut G-1012A, or approved equal supported directly from the bases. Support spacing shall not exceed 4 feet.

3. Grating: Mill-galvanized carbon steel in accordance with ASTM A525:
   a. Gauge 14-ga. steel.
   b. Section Width: 12 inches.
   c. Channel Height: 2 inches
   d. Flange Options: FM
   e. Surface Condition: MG-traction grip
4. Handrail: 12 gauge, 1-5/8 inch strut G-5812, or approved equal. Railing system shall be OSHA approved and shall be removable for access to larger components.
5. All substructures and handrails shall be galvanized steel. Spring nuts and bolts for spring nuts will be electro-plated.

C. Bases: Injection molded high density / high impact polypropylene with UV-inhibitors and anti-oxidants, conforming to the following:
   1. Moisture Content: Negligible.
   2. Shrinkage/Swelling Due to Moisture: Negligible.
   3. Density: 55.8 lb/cu ft (894 kg/cu m).
   4. Insect Resistance: No known insect damage potential.
   5. Chemical Resistance (oil, brake fluid, gasoline, diesel, antifreeze, battery acid, and sulfuric acid: No visual or physical change apparent.
   6. Flammability: No ignition after 10 minutes, 25 kW/m, when tested in accordance with ASTM D 1929.
   7. Sized as required by loading conditions and as indicated on the drawings.
   8. Shop fabricated with inserts for square tubing or threaded rods as required.
   9. Color: Integral black color as molded.
   10. Bases for Mechanical Attachment: Sealant chamber around penetration point, with injection port for sealing after fastening; beveled lip for sealant bead around entire diameter.
   11. Do not use bases containing carbonated plastics, press molded recycled rubber and plastics, steel, stainless steel, or any injection molded threaded receivers.

D. Steel Framing:
   1. Channel Types: 1-7/8 inch BTS22H, as required for loading conditions.
   2. Thickness: 12 gage (2.7 mm).
   3. Form: Roll-formed 3-sided or tubular shape, perforated with 9/16 inch (14.3 mm) holes at 1-7/8 inch (47.6 mm) centers on three sides.
   4. Finish: Hot dip galvanize in accordance with ASTM A 123 after fabrication, free of roughness, whiskers, unsightly spangles, icicles, runs, barbs, sags, droplets, and other surface blemishes.
   5. Do not use tubing or tube steel.

E. Accessories: Clamps, bolts, nuts, washers, and other devices as required for a complete system.
   1. Carbon Steel: Hot-dip galvanized in accordance with ASTM A 153/A 153M.

F. Installation:
   1. Install substructures at spacing indicated, but not greater than 4 feet on center.
   2. Locate bases and support framing as required for a completer and code compliant installation. Provide complete and adequate support of all structures.
   3. Accurately locate and align bases.
      a. Consult manufacturer of new roofing system as to the type of isolation pads required between the roof and base.
      b. Set isolation pads in adhesive if required by manufacturer's instructions.

c. Place bases on isolation pads.
d. Adhere or mechanically attach if required by code.

4. Set legs of substructures into bases as indicated.
5. Use galvanized fasteners for galvanized framing.
6. Layout and fasten planking to substructures.
7. Where handrails are required, install as follows:
   a. Install intermediate rails without tightening.
   b. Make minor adjustments as needed, such as spacing of substructures to accommodate intermediate handrails, and install hold-downs.
   c. Secure intermediate handrails and install top handrails.

2.48 HOISTING MACHINERY AND EQUIPMENT

A. All hoisting equipment, rigging equipment, crane services and lift machinery required for the work by this Trade Contractor shall be furnished, installed, operated and maintained in safe conditions by this Trade Contractor, as referenced under Section 01 50 00 - TEMPORARY FACILITIES AND CONTROLS.

2.49 AUTOMATIC TEMPERATURE CONTROLS

A. Furnish and install all control components necessary to obtain a fully functional control system as described herein. The contractor is responsible for providing all controls, relays, etc. necessary to accomplish the Sequence of Operations and performance specified, whether or not the items are specifically identified herein. This shall include all the points shown in the control diagrams and on the drawings. Wherever a setpoint is referred to, this implies that the setting is adjustable by the user. Contractor shall hire the project electrician to provide additional power supplies to support the control devices as required. All controls operating equipment and systems configured to run off emergency stand-by power must be wired to the emergency stand-by power circuit. Any controls supporting the stair tower pressurization fans or other life safety components shall be wired to life safety emergency power circuit. This shall include but not be limited to the following systems along with all associated control devices:
   1) front-end work station
   2) network controllers and interface
   3) boiler plant (boilers, pumps, ventilation, CO system)
   4) domestic water heaters and associated, boiler, tank and recirculation pumps
   5) IDF and MDF fan coil units
   6) Data center systems CRAC-1 & 2 and ACCU-1 & 2
   7) Emergency electric room fan coil units
   8) Chiller/Heater module, chiller heat and cool pumps and chilled water system pumps
   9) cabinet unit heaters & unit heaters
   10) RTU-6, 7, 8, 12, 12, 14, 18, 20, 21, 22, 23, 24 systems (DX cooling and dehum. disabled if on emergency power)
   11) Anti-stratification fans.
   12) Administration & Health Clinic systems RTU-10 and all associated ACHP's (ACHP-8) and fan coils;
   13) Kitchen MAU and Hood Exhaust Systems and associated devices;

   Provide battery UPS power supplies for the front-end and network interface controls to insure no interruption of the power supply. As indicated in section 01.60.00 Product Requirements, 1.6 Owner's Proprietary Products, the Alerton control system by ABS is a proprietary product and no alternates shall be allowed.

B. The specified DDC system shall be based the most recent generation of products by Alerton, as provided by Automated Building Systems, Inc. the Owners current energy management system provider. No alternates shall be allowed. Owner's front-end graphics must be updated to include this building with link to associated systems. The project graphics and software must be programmed into the existing city wide Alerton server. New controls installed must seamlessly integrate into the existing Alerton system front-end graphics for trending and alarm reporting. The control system shall operate on a central network bus and shall web based access via password protection to any remote computer. This control system shall be referred to as the DDC, EMS or ATC system throughout this specification. EMS system must be Bacnet and Open Protocol compatibility for direct communication with boilers, VFD's & RTU's, etc… to obtain operation status of systems including real time energy consumption. Besides various HVAC systems the EMS shall communicate to other building systems via BacNet ModBus RS-485 connection to monitor and report on status and energy use. The systems shall be as follows:
   - Lighting system (BACNet) – for occupancy/vacancy status of each room.
   - Generator (Modbus RS-485) – for monitoring various generator functions.
   - Submetering (Modbus RS-485) – for monitoring loads for each meter, some of which will have to be manipulated, and then displayed as graph or data.
   - Electrical metering software shall be installed on the EMS work station by the electrical contractor vendor with trending saved to the hard drive. Coordinate with electrical contractor.

   It is the intent of this project that most of the HVAC equipment such as rooftop units shall come stripped of most controls and devices for field installation of sensors**,** actuators and devices all provided by the EMS vendor. On rooftop equipment the only exception would be the compressor controller which would be furnished by the equipment manufacturer but must be interfaced with for control by the EMS. Although equipment may come with many local devices and sensors provided by the equipment manufacturer the EMS contractor must still provide external sensors and devices (i.e. duct smoke detector and damper connections, duct static and space static sensors, return and/or space CO2 sensors, etc…) as required to achieve the sequence of operation and comply with the bid documents. Controls subcontractor must review specifications and clarify with respective mechanical sub-bidders to verify mechanical contractor is proposing to provide the equipment specified with communication interface specified

C. The BMS contractor shall be regularly engaged in the installation and maintenance of BMS systems and shall meet the following qualifications:

   i. A minimum of ten (10) years of demonstrated technical expertise and experience in the installation and maintenance of BMS systems similar in size and complexity to this project.
   ii. A minimum of ten (10) years' experience installing the control system of the manufacturer that is to be proposed.
   iii. Shall be a certified-to-install, direct representative of a control system manufacturer that has a minimum of ten (10) years experience producing control systems similar to that which is to be proposed.
   iv. A maintained service organization consisting of at least eight (8) competent servicemen, within 60 miles of the project site, for a period of not less than ten years.
   v. Tech support available 24 hrs / per 365 day's per year.
   vi. The Bidder shall not be considered qualified to bid this project unless they can provide a list of 10 projects, similar in size and scope to this project, completed within the last four years.

7. The system manufacturer/installer shall provide an experienced project manager for this work from beginning of control installation until final completion. The project manager is responsible for direct supervision of the design, installation, start-up and commissioning of the BMS as well as attending of project meetings whenever directed by the owner, construction manager, and/or mechanical contractor. It shall not be acceptable to change the project manager after the project has begun and before final completion. If the BMS manufacturer wishes to change the project manager, the construction manager and/or owner's representative must be notified immediately and both the new project manager and the previous project manager shall spend 3 consecutive business days together on-site performing a project management switchover. Exceptions may be allowed for small projects as determined by the construction manager and/or owner's representative.

D. The entire system, materials & devices as well as installing contractor and associated work shall comply with all current governing codes, ordinances and regulations including UL, NFPA, NEC, IBC, IMC, local AHJ, etc…

E. The system shall have a documented history of compatibility by design for a minimum of 15 years. Future compatibility shall be supported for no less than 10 years. Compatibility shall be defined as the ability for any existing control system component including but not limited to Primary Control Panels, Secondary Control Panels, personal operator workstations, and portable operator's terminals, to be connected and directly communicate with any new BMS system equipment without bridges, routers or protocol converters.

F. All control wiring shall be shielded plenum rated minimum 18 AWG (unless lighter gauge or heavier gauge is required due to impedance or current demands) and shall be run concealed above ceilings or within walls. When the wiring must run exposed it shall be run in EMT conduit in unfinished service spaces and in Wiremold® or equal conduit system product in finished occupiable spaces.

G. It shall be division 23 00 00 responsibility to provide all personnel as required to fully coordinate with the commissioning agent. The hours of training and instruction outlined in division 23 00 00 and the Testing and Balancing requirements shall be in addition to those tests and requirements outlined in section 01 91 00 and required to fulfill section 01 91 00 commissioning obligations.

H. General

1. The automatic temperature control system shall include, but not be limited to, the following components:
   - Front-end computer with graphic software showing all building HVAC systems. Real-time interface with controlled components.
   - Several stand-alone DDC control unit(s) networked together on a local LAN to control the environment in the entire building
   - Expansion modules for the controllers, if required, shall provide for the capability of additional DDC points.
   - End devices such as sensors, actuators, dampers and valves.
   - Control transformers and relays.
   - Control wiring between duct smoke detectors and the respective fan starters.
2. The failure of any single component shall not interrupt the control strategies of other operational devices.

I. OPERATOR INTERFACE / STATION

1. Provide one main Front-end workstation which shall include the following:
   - Windows operating system compatible computer with Intel 8th Generation Core i5 processor (or equal AMD) 2.8 gigahertz speed.
   - 1 TB Hard Drive
   - 8 GB RAM
   - Dedicated Intel UHD 630 graphics Card (or equal AMD) and 22" flat screen color monitor
   - Keyboard
   - 48X CD-ROM/ REWRITE drive
   - 2 button mouse with scroll wheel
   - 10/100/1000 Ethernet Network Card
   - Wireless Card
   - Windows 10 software (or other as required by EMS)
   - Color Ink Jet Printer
   - 2 cartons of 1000 sheets bright white ink jet paper
   - Software including: dynamic color graphics; database creation and support; password access levels; alarm processing; data collection and trending; etc..
   - Back-up discs of all software and programming.

J. INPUT/OUTPUT INTERFACE

1. Digital Inputs (DI) shall allow the monitoring of on/off signals from remote devices. The digital inputs shall provide a wetting current of 12mA at 12 vdc to be compatible with commonly available control devices.

2. Analog Inputs (AI) shall allow the monitoring of low voltage current or resistance signals and shall have a minimum resolution of 0.1% of the sensing range. Analog inputs shall be compatible with and field configurable to commonly available sensing devices.

3. Digital Outputs (DO) shall provide a continuous low voltage signal for on/off control of remote devices. Where specified in the sequences of operations or indicated on the points list, digital outputs shall have 3-position (on/off/auto) override switches, status lights, and shall be selectable for either normally open or normally closed positions.

4. Analog Outputs (AO) shall provide a modulating signal for the control of end devices. Outputs shall provide either a 0 to 10vdc or a 4 to 20 mA signal as required to provide proper control of the output device.

K. AUXILIARY CONTROL DEVICES

1. Control Valves

   a. Valve bodies shall be 2-way or 3-way mixing as shown on the drawings and as specified herein. Valve bodies 2" and under shall be bronze, screwed type, rated for 125 psig. Valve bodies 2-1/2" and over shall be iron, flanged and rated at 125 psig, except where otherwise noted. Valves shall have stainless steel stems and allow for servicing including packing, stem and disk replacement. Valve shall be sized for a pressure drop equal to 2 psig.

2. Valve Actuators

a. Valve actuators shall be electronic, spring return, low voltage (24v) and properly selected for the valve body and service. Actuators shall be fully proportioning. All heating valves including radiation shall be fail open style to open fully upon power loss however during summer months when the heating plant is off, the ATC shall disable power to the valves.

3. Dampers and Actuators

a. Dampers shall be opposed blade type except where installed in round ductwork where single blade type is acceptable. All damper blades shall be low leakage type with neoprene gasketed edge seals rated for no more than 3 CFM/SF leakage at 1" w.g.. Actuators shall be electronic, spring return, low voltage (24v) and properly selected for the required torque and speed. Actuators shall be fully proportioning with the exception of those dampers specified as being 2-position open & closed. All actuators shall include end switches. Those dampers for the stair tower pressurization system shall include end switches for both full open and full closed positions.
b. Dampers exposed to the area served shall be double wall insulated ultra-low leakage type.

4. Temperature Sensors

a. Temperature sensors shall be Resistance Temperature Detector (RTD) type or thermistors, as dictated by the requirements of this specification. Final location of all space sensors shall be coordinated with the Owner and Engineer. Space sensors in classrooms, offices, teacher lounges and non-public spaces shall be wall mounted type with a user adjustable access allowing deviation of +/- 3 deg. of computer defined setpoint and push button occupied override. Space sensors in public areas such as in the Gymnasium, Locker Rooms, Cafeteria, Lobby, etc… shall be non-adjustable type with push button occupied override. Sensors in gymnasium and locker room shall be stainless steel plate type with push-button override. Sensors in restrooms shall be stainless steel plate type with no override.

b. Duct sensors shall be rigid or averaging as specified in the sequence of operations. Averaging sensors shall be a minimum of 20 feet in length. Freeze protection sensor shall have a 20 foot sensor crossing back and forth across the air exit face of the water heating coil. Immersion sensors shall be provided with a separable stainless steel well

c. Sensor accuracy's and operating ranges shall be as follows:
- Space temp. +/- 1 deg. F, 0 to 130 deg. F range
- Duct temp. +/- 1 deg. F, 30 to 160 deg. F range
- O.A. Duct temp. +/- 1 deg. F, -30 to 160 deg. F range
- Water +/- 1 deg. F, 0 to 200 deg. F range

5. Relative Humidity Sensors

a. Relative humidity sensors shall be thin film capacitor type with an accuracy of +/- 2% with a range of 10% to 90%. For enthalpy calculations provide on North wall for outdoor air sensing and one in each RTU and AHU main return air duct and elsewhere as shown on the control drawings or indicated herein. Final location of

all space sensors shall be coordinated with the Owner and Engineer. Space sensors shall be wall-mounted type.

6. CO2 sensors: Shall be self-calibrating duct or wall-mounting type as specified capable of measuring a CO2 range between 100 and 2000 PPM as manufactured by Mamac or approved equal.

7. Flow Switches

   b. Differential pressure switches shall be provided at filters and fans. Paddle type switch shall be provided at boilers unless otherwise noted or if boiler flow turn down is below range of paddle sensor. Current sensing run indicators shall be provided at each fan and pump. Sensor shall be able to differentiate between belt loss and motor failure and report to the workstation as such.

8. Air Flow Measuring Stations: Provide multi-point cross grid hot wire flow measuring station at return air duct main on each RTU and AHU. Devise shall be similar to Ebtron Gold series. Outdoor air intake, exhaust fan and supply air fan airflow stations shall be furnished by the RTU & AHU equipment manufacturer.

9. For all EVAV terminals (and select VAV terminals) where scheduled to operate at a minimum airflow below pitot limits provide an Ebtron #EF-x1000-T airflow station. EVAV's shall be ordered without there flow station with the Ebtron unit field installed.

10. Water Flow Measuring Stations: Provide ultrasonic water flow measuring stations in the mains of the hot water systems to calculate system GPM flow with +/- 2% accuracy across full range of flow from maximum to a minimum flow rate of 15% of maximum.

11. Duct Smoke Detectors: HVAC contractor shall install duct smoke detectors in ductwork as well as interlock with respective fan circuits and EMS system. Electrical contractor shall furnish duct smoke detector, power wire and wire to fire alarm system.

12. Fire/Smoke Dampers: Coordinate control of fire/smoke fire smoke dampers with electrical contractor. When a fire/smoke damper closes in an area the respective unit serving that area shall shutdown. Electrical contractor shall wire fire/smoke dampers to the fire alarm system.

13. Stair Tower Pressurization System: All controls related to the stair tower pressurization systems shall be UL 864 listed. The fire alarm contractor shall provide the the smoke control graphic annunciator panel (see plans) and provide enabling and monitoring relays for the panel. The stair tower fan controls, as they relate to the space pressure controls, VFD fan speed control, pressure relief dampers and intake isolation dampers shall be furnished and installed by the ATC contractor. Enabling/disabling of the systems, status and manual override features shall be wired to the smoke control panel. The stair tower pressurization systems shall be enabled and disabled by their interface to the fire alarm system (FACP). The FACP shall be directly wired to control the VFD. The VFD shall be programmed and wired by ATC to send an open signal to intake and relief dampers upon FACP activation and prove intake damper opening prior to allowing VFD to ramp up fan. Once enabled, the EMS system shall control the fan speed as specified herein.

14. At each fume hood furnish and install fume hood monitoring and control unit with electronic duct damper, sash airflow monitor and alarm as manufactured by Phoenix

controls model #FHM631-ENG with #EXV-A-F-14-M series valve with high-speed operator or equal by TSI or Johnson Controls. Unit must have a hibernate mode which can be activated by command on the hood monitor and by the EMS to disable the alarm controller and close the valve to minimum position (100+/- CFM) if the sash if closed. Unit shall automatically go out of hibernate mode if the sash is opened.

15. Furnish and install a CO detection and alarm system in boiler plant. The system shall consist of a central control/annuciator panel and a remote CO sensor as shown on the drawings. The system shall communicate with the building EMS. System shall be as manufactured by Toxalert, Viking or MSA. CO sensor shall have solid state sensing element with a 0-400 ppm range, 10-year warranty, automatically calibrating, Toxalert model TOX-CO/ANA with controller model ToxControl. System shall automatically compensate for temperature and send a 0 to 10vdc and digital signal to the building EMS for control of ventilation and monitoring. Provide NEMA 1 enclosure, status lights, 85 dB audible alarm and visual strobe. EMS shall provide all wiring between sensor, panels, alarms, fans, EMS, etc…

16. At each chilled beam unit, sensible fan coil and sensible FVAV unit provide a moisture sensor in the condensate pan. Sensor shall be of the type able to detect water at depths of 1/16”. Devices shall be wired to close the respective units chilled water valve if water is detected. For rooms with multiple chilled beam terminals, only one sensor need to be provided per room.

17. CARBON MONOXIDE / NITROUS OXIDE DETECTION SYSTEM

    A. Provide a Carbon Monoxide & Nitrous Oxide Detection within the parking garage area and CCL shop for control of ventilation (via EMS communication) and to provide an alarm signal when a hazardous level of CO or NOx is detected. The systems shall be furnished by a single manufacturer as a complete system from a single manufacturer.

    B. The Carbon Monoxide / Nitrous Oxide Detection System for each area shall consist of a central control/annunciator panels with integral horn & strobe light, multiple remote horn/strobe lights and multiple remote CO sensors, multiple remote NOx sensors and multiple remote volatile fuel sensors FG.

    C. ACCEPTABLE MANUFACTERS

        1. Manufactures shall have local representation experienced with Carbon Monoxide Detection Systems and minimum of ten (10) continuous years of active service. A local supply of spare parts and authorized factory repair service shall be available.

        2. List of Manufactures:
            a. Toxalert, Inc.
            b. Vulcain.
            c. Honeywell.
            d. Approved equal.

        3. Specification has been based around Toxalert. Local representative is Air Distribution Corporation. Contact: Mark Persechini Telephone number: 508-588-9595

D. CARBON MONOXIDE SENSORS (CO) & NITROGEN OXIDE SENSORS (NOx)

1. The CO and NOx sensors shall output a linear 4 to 20 ma analog signal proportional to the CO or NOx gas levels detected to the controller and shall have a normal operation range of –20 deg. F. to 122 deg. F. and 0 to 95%R.H. non-condensing. The sensor shall have a range of 0 to 250 PPM for CO and 0 to 10 for NOx, with an accuracy of +/- 3% of range. The sensors shall be microprocessor based with twelve (12) bits analog/digital resolution and periodically recalibrate itself.

2. The CO and NOx sensors shall have a solid-state sensing element for life of ten (10) years and shall be microprocessor based and be self-monitoring of proper operation. The temperature thermistor will automatically compensate the output signal for changes in ambient relative humidity and temperature.

3. The CO and NOx sensors shall have indicators for: 1) power on; 2) automatic calibration/operating properly; 3) sensor malfunction; 4) high CO or NOx alarm.

4. The sensor enclosure shall be a NEMA 1 removable hinged cover cabinet, with a keyed lock to prevent tampering. An aluminum splash/dust shield on the face of sensor to protect sensing element.

5. The sensor shall be powered by 24 VAC, 4 wire, 18 gauge shielded.

6. Sensors shall be located as indicated on the drawing(s).

7. Carbon monoxide sensor shall be a model TOX-CO/ANA as manufactured by Toxalert, Inc.

8. Notrogen Oxide/Dioxide sensor shall be a model TOX-NO2/ANA as manufactured by Toxalert, Inc.

E. CONTROLLER/ANNUNCIATOR

1. Provide a controller to monitor carbon monoxide sensors. The controller shall contain power supplies, solid-state control logic, amplifiers, and output to start and stop the ventilation fans. The controller shall be designed to be wall mounted for visual and audible alarm indication.

2. The controller shall be microprocessor based and utilize battery back-up to ensure system programs are not lost during power interruption.

3. The controller shall be capable of fan start/stop damper open/close operation from a high space temperature.

4. Fan ON delays can be programmed from one (1) to ninety-nine (99) seconds. Power input to control panel should be 120V/1PH/60HZ.

5. The controller and sensors shall be mounted as shown on drawings.

6. Provide labeled indictors on the face of the controller panel for 1) power ON, 2) high CO level, 3) NOx level, 4) fan ON; and 5) power to each sensor.

7. Provide an audible alarm for each sensor with a sound level minimum of 85 db. Also, provide a momentary pushbutton to silence the audible alarm. The visual alarm indicator shall remain lighted as long as the alarm condition persists even though the audible signal has been silenced.

8. The controller shall have all the necessary power supplies and transformers to supply power to CO and NOx sensors.

9. System controller shall be a Toxalert, Inc. Model TOC-CO Series controller.

F. CONDUIT AND WIRE

1. Conduit and wiring shall be as indicated on the plan(s) and meet all local and national codes. Signal wiring shall be a minimum size of #18 AWG for sensors.

2. All wiring shall run in EMT conduit. Provide weatherproof conduit in exterior locations and in the wash bay.

G. INSTALLATION

1. This contractor shall provide all conduit, wiring, and junction and outlet boxes as required for a complete system.

2. Electrical contractor shall provide 120 VAC power to the CO detection system.

H. TESTS AND ADJUSTMENTS

1. A representative of the manufacturer shall be present with the contractor to check out and start up the system per manufacturer recommendations.

2. Perform an actual CO and NOx system test using CO and NOx gas cylinders. The test will be witnessed by the engineer and other interested parties.

18. Each kitchen hood (typical of two hood banks), is being furnished with a smoke/heat detection system as manufactured by Halton Marvel or equal by Intelli-Hood® controls by Melink® by Kitchen equipment vendor. Each system shall include 1)keypad control of hood ventilation system interfaced to EMS, 2) hood optic sensors to fully monitor the area under/within the hood, 3) exhaust duct temperature sensor, 4) space temperature sensor, 5) I/O processor with interface to EMS. For a single fan serving multiple hoods, sensors shall be provided for each hood and the fan speed shall drive off the hood with greatest demand. The hood controller for each hood shall be installed per manufacturer's instructions. The hood manufacturer is providing a utility cabinet with the system controller and VFD drives. Controller shall report status, alarms and exhaust CFM to the EMS. EMS must wire to controller for proper fan operation and make-up air unit operation. Make-up air unit shall be configured to track exhaust air volume within allowable control limits.

L. OPERATOR INTERFACE SOFTWARE

1. Alarms

a. The stand-alone DDC unit shall provide visual notification of equipment failures, program failures, hardware failures or sensor failures. In addition each sensor and

point shall be individual alarmed for values in excess of their respective high/low limits or status. When an alarm is detected, it shall be automatically stored and the user notified by displaying a message on the front display panel. The front-end shall be located in the Maintenance Office.

b. In addition to visual notification, an audible alarm shall sound during a high-level alarm condition as follows:
- Duct smoke detector activated
- Fan failure
- Pump failure
- Boiler failure
- Freeze stat protection alarm
- CO and NOx alarm
- Cooler Prep Room CO2 Alarm
- Cooler Prep room Refrigerant alarm
- Low space temperature (lower than 50°F)
- High space alarm (greater than 100°F)
- Freezer and Refrigerator temperature alarms

c. The audible alarm shall be mounted in a location as directed by the Owner. A toggle switch or push button shall be mounted adjacent to the alarm with a laminated plastic tag noting “HVAC Alarm: Silence – Auto”. Once alarm condition subsides the alarm shall be automatically reset. This alarm shall be in addition to those local alarms provided for CO & Refrigerant alarms.

d. Filter Alarms:

If filter differential static pressure sensor detects a filter pressure drop of greater than a setpoint of 0.7” a dirty filter maintenance alarm shall be reported by the front-end. Typical for all system with filter monitoring as indicated on the control drawings.

2. Scheduling

a. The scheduling program in the stand-alone DDC unit shall provide daily, weekly and calendar scheduling capability. The master schedule shall be capable of being individually edited for each day of the week and holidays.

3. Communications

a. The controller shall communicate on a network bus. In addition, the system shall communicate to the internet via a Ethernet connection. Coordinate with Owner for Ethernet interface port. Contractor shall program system to dial out and email alarms to predefined parties and send alarms to the Owner’s security monitoring company.

4. Energy Monitoring

At both the Owner’s workstation and the workstation at the Owners Informational Kiosk provide software and graphically trends as required to display system operational status and energy consumption of boilers, chillers, air handlers, system BTU loads, lighting power consumption and solar power Watt energy generation. Graphs shall report energy consumption/generation in BTU, Watts and kW over time.

Energy data from the HVAC equipment and system shall be derived from the applicable fan and pump VFD drive kW information as well as BTU data from the airflow and water flow stations and applicable temperature and humidity sensors (humidity sensors used for airflow BTU energy). In addition, the EMS shall provide monitoring devices to track the natural gas consumed by the domestic hot water heaters and the heating boilers on a real time and totalized basis using pulse metering retrofitted to gas sub meters. The gas meters shall be furnished and installed by the plumbing contractor and the pulse meters shall be installed by the control contractor. Plumbing contractor shall install gas sub meters on the main gas line to the boiler plant and the branch gas line to the domestic water heaters. Heating boiler gas usage shall be determined by subtracting the domestic water heater gas meter reading from the boiler plant gas meter reading. The pulse meters shall be similar to the 'X'-pulser manufactured by IMAC Systems, Inc. compatible with the gas meter furnished by the plumbing contractor

Besides various HVAC systems the EMS shall communicate to other building systems via ModBus RS-485 connection to monitor and report on status and energy use. The systems shall be as follows:

- Lighting system (BACNet) – for occupancy/vacancy status of each room.
- Generator (Modbus RS-485) – for monitoring various generator functions.
- Submetering (Modbus RS-485) – for monitoring loads for each meter, some of which will have to be manipulated, and then displayed as graph or data.

The system shall be fully capable of being programmed to load shed the DX cooling of various systems based on maintaining building kW demand below a preset limit. Unless otherwise directed as a minimum the programming shall prioritize the DX cooling drop as follows: 1st Drop Gym cooling, 2nd Drop kitchen cooling 3rd Drop Café cooling. Further system shedding shall be reviewed with Owner.

5. Generator Monitoring:

   a. Integration to Building Management System (BMS):

      1) Electrical contractor shall provide Modbus RS-485 communications wiring from the generator to:
         - BMS system.
         - Generator Annunciator.

      2) The BMS system shall monitor the following points:
         - Overcrank shutdown
         - Low coolant temperature warning
         - Pre-warning for high engine temperature
         - High engine temperature shutdown
         - Pre-warning for low lube oil pressure
         - Low lube oil pressure shutdown
         - Overspeed shutdown
         - Low fuel in main tank warning
         - Low coolant level warning
         - Generator (EPS) supplying load.
         - Generator control switch not in auto position warning
         - High battery voltage warning

- Low cranking voltage warning
- Low battery voltage warning
- Battery charger failure
- Generator output breaker(s) open warning
- Emergency stop depressed
- Load Bank Connected
- Load Bank Over-Temperature
- Load Bank Load Dump
- Permanent generator Disconnected/Portable Generator (signal from manual transfer switch)
- Spare/Customer alarm
- Spare/Customer alarm

b. The electrical contractor shall provide wiring from the BMS system to the generator for the load bank “transfer of control” contact closure to initiate the load bank and time delay load application circuit.

c. The electrical contractor shall provide wiring from the generator to the BMS for indication, detection and alarm of Load Bank Over-Temperature and Load Dump.

d. Coordinate exact requirements with the electrical vendor.

6. Fault Detection and Diagnostics:

The EMS shall include analytical software to support fault detection and diagnostics of the EMS system. Software shall be similar to Niagra WEBs-N4 Analytics, current version. Software shall include an algorithm library editable to match the current applications within the building and shall be set up to monitor, trend and report on operation issues.

M SEQUENCE OF OPERATION – HYDRONIC HEATING BOILERS & BOILER PUMPS

1. The hydronic gas-fired boiler/burner units shall be controlled by a microprocessor based pre-engineered and programmed control system furnished by the boiler manufacturer. The control system shall be furnished as specified in this specification for Boiler/Burner Units. All boiler/burner control wiring from burner control panels to multiple boiler control system, boiler circulators, primary controls, operating controls, limits, switches, and additional control devices as required shall be furnished and installed by the Automatic Temperature Control Contractor per manufacturer's instructions. The boiler controller shall have system supply and return water sensors and outdoor air sensors wire directly to the factory panel.

2. Boiler controller shall be set to achieve supply water temperature reset indicated below while optimizing the energy consumption of the plant. Boiler controller shall initiate respective boiler primary pump prior to firing respective boiler and shall operate primary pump for a preset duration (initially 30 seconds) after boiler is disabled.

3. The DDC shall monitor the boilers via BacNet or open protocol software but as a minimum interface must allow user to view all operating points, firing rates, energy consumptions, etc.…

4. Boilers system shall be enabled when the system pumps are on, the system is in the heating mode and there is a call for heat from the hot water loop. In general, the boiler plant shall only be enabled at outdoor temperatures below 60 degrees F. and only if the hot water loop temperature cannot be maintained by the heat recovery chiller-heater. Boilers shall modulate fire on their integral control system resetting HW temperature based on outdoor air temperature HW temp. shall be reset as follows. Boilers shall operate in an energy optimization mode and lead/lag to insure even run time.

O.A.Temp	Supply Temp.
5°F	130°F
60°F	95°F

5. When a boiler is called to fire its respective boiler pump shall enable and prove on prior to the boiler firing. When a boiler is disabled the respective pump shall operate 30 seconds to purge the boiler of hot water. Boiler controller shall vary speed of respective boiler pump to maximize boiler efficiency.

6. EMS shall monitor system flow via a flow measuring station and report flow back to front-end for calculation with temperature differentials to achieve BTU energy consumption.

7. Provide two (2) remote shutoff switches for the boiler room. One switch shall be located just outside the interior door to the boiler room. Switch must be located in a break glass or equal tamper resistant enclosure properly labeled. The second switch should be located just inside the boiler room exterior door properly labeled as to its service. Switches must be wired and programmed so that when either switch is placed in the off position a disable signal shall be immediately sent to all of the heating boilers and domestic hot water heaters.

7. DDC Point List - Hydronic Boiler Control

   As a minimum, the following points shall be hard wired monitored and controlled although, the front-end shall be capable of viewing all boiler points through BacNet.

Inputs:	Output
O.A. temperature AI	Boiler system enable/disable DO
Common HW supply temperature AI	Hot water reset AO
Common HW return temperature AI	Boiler Pump AO (3) via boiler controller
Boiler flame failure DI (3)	
Boiler status DI (3)	
Boiler Pump Status (3) DI	
Hot water system flow GPM AI (2)	
Main Hot Water Return Temp AI	
Main Hot water Supply Temp AI	
Boiler Enable/Disable Command DI (3)	
Boiler firing rates, temps and Energy data (via BacNet)	
Boiler Safety Shut-Off DI (2)	

N. SEQUENCE OF OPERATION – SYSTEM HEATING PUMPS (P-4A thru P-4D)

1. Whenever the system is in heating mode the pumps shall operate. Heating mode shall be enabled when outdoor air temperature drops below 65ºF (adjustable). Heating

mode shall also be enabled if any of the chilled beam RTU systems (RTU-1 thru 4), the Science room RTU systems (RTU-6 and 8) or the ETA fan coil systems require heating or reheating beyond the capabilities of the RTU's integral heat pump heat or reheat (i.e. spaces are overcooling), this enable mode feature can be enabled or disabled per a graphic enable/disable function entitled "Warm Weather Heat Enable/Disable". Once enabled, a start command shall be sent to the respective pump package controller and the controller shall enable the number of pumps required to achieve the flow demand. Whenever the outdoor air temperature is above the heat enable setting, the pumps shall remain off. During summer unoccupied periods the system pumps shall remain off. During winter unoccupied periods, if all the building zones are satisfied and the outdoor air temperature is above 48ºF the pumps may cycle on & off as needed. During this mode pumps shall only cycle on if more than 3 zones (adjustable) are calling for heat. If all the heating system pumps are off the boiler plant shall be disabled.

2. If a pump fails as sensed by the factory control package, the standby pump(s) shall be energized and an alarm shall be initiated through the DDC via the pump package BacNet interface

3. The factory pump package controller shall alternate (lead-lag) the pump operation on a run-time bases to provide equal service and wear on the pumps as well as stage and modulate the pumps required to meet the system demand while using the least electrical pump energy required (energy optimization). In general lead/lag pumps shall rotate every 72 run hours.

4. EMS shall monitor system flow via a flow measuring station and report flow back to front-end for calculation with temperature differentials to achieve BTU energy consumption.

5. The pump package controller shall stage pumps and vary the ECM pump speeds as required to maintain constant system differential pressure while optimizing energy consumption. The EMS shall send the pump package a 4-20 mA or 0-10Vdc signal based on maintaining system differential pressure.

6. DDC Point List – Heating System Pumps
   As a minimum, the following points shall be monitored and controlled:

Input	Outputs
	Pump Package P-4A thru D Speed AO
	Pump Package P-4A thru D Start/Stop DO
System Diff. Press AI #1	
Flow Station AI #1	
Main HWR Temp. AI	
Main HWS Temp AI	
Alarms, Status and Energy Data (via BacNet) typ. pump packages	

O. SEQUENCE OF OPERATION – HOT WATER TO GLYCOL HEAT EXCHANGER & PUMPS (P-5A thru P-5C)

1. Whenever the main heating system is active and any of the RTU or MAU units require main unit coil heat above what the unit can provide via its heat pump cycle as applicable. Whenever outdoor air temperatures drop below a setpoint of 15°F (limit of most non-custom RTU air-cooled heat pumps) the HX system shall be enabled. Note: The MAU

unit has no heat pump cycle and, if enabled, shall require the HX pump system to be enabled to support heating.

2. Once the HX system is enabled, a start command shall be sent to the respective pump package controller and the controller shall enable the number of pumps required to achieve the flow demand. Whenever the main system heating pumps are off the pumps shall remain off.

3. If a pump fails as sensed by the factory control package, the standby pump(s) shall be energized and an alarm shall be initiated through the DDC via the pump package BacNet interface

4. The factory pump package controller shall alternate (lead-lag) the pump operation on a run-time bases to provide equal service and wear on the pumps as well as stage and modulate the pumps required to meet the system demand while using the least electrical pump energy required (energy optimization). In general lead/lag pumps shall rotate every 72 run hours.

5. Once the water flow has been proven, the HX water valve shall modulate to maintain hot water setpoint reset off of outdoor air as follows:

Outdoor Air Temp.	Hot Water Supply Temp.
10°F	125°F
60°	95°F

6. EMS shall monitor system flow via a flow measuring station and report flow back to front-end for calculation with temperature differentials to achieve BTU energy consumption.

7. The pump package controller shall stage pumps and vary the ECM pump speeds as required to maintain constant system differential pressure while optimizing energy consumption. The EMS shall send the pump package a 4-20 mA or 0-10Vdc signal based on maintaining system differential pressure.

8. DDC Point List – HX System
   As a minimum, the following points shall be monitored and controlled:

Input	Outputs
	Hot Water Valve AO
	Pump Package P-#5A thru C Speed AO
	Pump Package P-#5A thru C Start/Stop DO
HX System Diff. Press AI	
HX Flow Station AI	
HX HWS Temp. AI	
HX HWR Temp AI	
Alarms, Status and Energy Data (via BacNet) typ. each pump packages	

P. SEQUENCE OF OPERATION – CHILLED BEAM PUMPS AND INJECTION LOOPS

1. Whenever the chilled water system is active and there is a call for cooling from the respective chilled beam systems the respective pump set shall be enabled.

2. A start command shall be sent to the lead pump and the pumps shall control to maintain loop differential pressure setpoint (set during balancing). If the RTU serving the respective chilled beams is not operating the pump shall be disabled.

3. If a pump fails as sensed by the factory control package, the standby pump(s) shall be energized and an alarm shall be initiated through the DDC via the pump package BacNet interface

4. The EMS shall alternate (lead-lag) the pump operation on a run-time bases to provide equal service and wear on the pumps. In general lead/lag pumps shall rotate every 72 run hours.

5. Once the water flow has been proven, the injection valve shall modulate to maintain a chilled water setpoint of 57°F.

6. EMS shall monitor system flow via a flow measuring station and report flow back to front-end for calculation with temperature differentials to achieve BTU energy consumption.

7. The EMS shall vary the ECM pump speeds as required to maintain constant system differential pressure while optimizing energy consumption.

8. DDC Point List – Chilled Water Injection System
   As a minimum, the following points shall be monitored and controlled:

Input	Outputs
	Injection Valve AO
	Pump Speed AO
	Pump Start/Stop DO
Chilled Water System Diff. Press AI	
CHWS Flow Station AI	
CHWS Temp. AI	
CHWR Temp AI	
Alarms, Status and Energy Data (via BacNet) typ. each pump	

P. SEQUENCE OF OPERATION – CHILLER-HEATER (CH-1)

1. The chiller-heater provides both cooling and heating to areas requiring such. The building shall have some level of cooling load demand 24 hours per day, 7 days per week and as such the cooling side of the chiller shall remain enabled continuously. The heating side of the chiller-heater shall only be enabled if there is a call for heating from the heating plant.

2. Once enabled by the ATC into either cooling mode, heating mode or both, the chiller-heater shall enable one of its two primary pumps sets (4 pumps total) and upon proof of flow through the chiller-heater, the unit shall operate on its integral factory controls to maintain chilled water and hot water setpoints. Chiller heating and cooling pumps shall alternate every 72 running hours to insure even service and wear. Pumps shall modulate flow based on system demand and minimum chiller-heater flow requirements.

3. The chiller-heater shall operate on its own internal controls, modulating capacity to maintain a supply water temperature setpoint as reset by the ATC which for chilled water shall be between 50°F & 55°F and for hot water is 100°F and 130°F (see reset schedule below). If chilled water side supply water temperature falls below 38°F, or if proof of flow is not maintained the ATC shall disable the chiller mode or hot water mode or both based on failure. System shall re-enable chiller water side once chilled supply water temperature rises 5°F above setpoint and adequate water flow is proved. Internal time-outs and safeties of the integral chiller controls shall not be bypassed.

4. When generating hot water, the water to water heat pump mode of the chiller shall be capable of operating regardless of outdoor air temperature subject to manufacturers limitation. The air to water heat pump heating mode of the chiller shall be limited to a setpoint of 15°F or as otherwise noted by the chiller-heater manufacturer.

5. Once the water flow has been proven, the EMS shall send a chilled and/or hot water supply setpoint to the chiller and the chiller shall stage as required to maintain water setpoints as follows:

   Hot water setpoint reset off of outdoor air as follows:

Outdoor Air Temp.	Hot Water Supply Temp.
10°F	130°F
60°	95°F

   Chilled water setpoint shall be fixed at 50°F with the ability to reset up to a maximum of 55° subject to maintaining the system chilled water setpoint of 57°F.

6. Contractor shall install and field wire high limits, low water cut-offs, flow switches and vent dampers. Chiller shall not be allowed to start if all safeties have not proved and the respective vent dampers have not proved open. If required by code, the contractor shall hire a licensed electrician to perform the necessary wiring and/or controls work.

7. Points List for Chiller-Heater (see also pumps):

   DDC Point List - Hydronic Chiller-Heater Control

   a. As a minimum, the following points shall be hard wired monitored and controlled although, the front-end shall be capable of viewing all boiler points through BacNet.

Inputs:	Output
O.A. temperature & Hum AI(2)	Chiller system enable/disable DO
Hot Water supply temp. AI	Hot water reset AO
Hot Water return temp. AI	Heat Pump En./Dis. & Speed DO/AO
Chilled Water Supply Temp AI	Chiller Pump En./Dis. & Speed DO/AO
Chilled Water Return Temp AI	Chilled Water Reset AO
	Heating Mode Enable/Disable DO
	Cooling Mode Enable/Disable DO

   Chiller status DI
   Chiller Pump Status (4) DI
   Chiller capacity rates, temps and Energy data (via BacNet)
   *Note: Chiller pumps controlled by chiller-heater controllers

Q. SEQUENCE OF OPERATION – CHILLER HEAT EXCHANGERS & PUMPS (P-10A,B,C)

1. When the chiller is enabled into cooling or heating or both modes the respective heat exchanger shall be enabled.

2. The heating mode of the chiller-heater shall be active whenever there is a call for heating from the building as noted under the boiler sequence. The chiller-heater shall be considered the 1st stage of heat followed by the boilers as needed.

3. Once the chiller is enabled in cooling mode the HX-2 system pumps P-10A,B,C shall be enabled, a start command shall be sent to the respective pump package controller and the controller shall enable the number of pumps required to achieve the flow demand.

4. If a pump fails as sensed by the factory control package, the standby pump(s) shall be energized and an alarm shall be initiated through the DDC via the pump package BacNet interface

5. The factory pump package controller shall alternate (lead-lag) the pump operation on a run-time bases to provide equal service and wear on the pumps as well as stage and modulate the pumps required to meet the system demand while using the least electrical pump energy required (energy optimization). In general lead/lag pumps shall rotate every 72 run hours.

6. The chilled water HX-2 valve shall modulate as needed to maintain a setpoint 7°F above the chillers chilled water setpoint. Hence if the chillers setpoint is 50°F the chilled water loops setpoint shall be 57°F. The loop temp shall not reset below 57°F as it supports sensible only coils.

7. When the chiller is enabled into heating mode either alone or simultaneously with cooling The CH-1 hot water pump set shall enable and run off factory controls. The HX-3 CH-1 side valve shall modulate as needed to maintain a setpoint reset off of outdoor air as follows (note the supply temp. is upstream of the boilers and main system supply sensor):

Outdoor Air Temp.	Hot Water Supply Temp.
10°F	125°F
60°	95°F

8. The system side hot water HX-3 valve shall modulate to maintain a maximum flow rate thru the HX-3 of no greater than 320 GPM (adj.) at all times.

9. EMS shall monitor system flow via a flow measuring station and report flow back to front-end for calculation with temperature differentials to achieve BTU energy consumption.

10. The pump package controller shall stage pumps and vary the ECM pump speeds as required to maintain constant system differential pressure while optimizing energy consumption. The EMS shall send the pump package a 4-20 mA or 0-10Vdc signal based on maintaining system differential pressure.

11. DDC Point List – HX System
    As a minimum, the following points shall be monitored and controlled:

Input	Outputs
	Chilled Water Valve AO
	Pump Package P-10A thru C Speed AO
	Pump Package P-10A thru C Start/Stop DO
Hot Water Valve HX-3, CH-1 side AO	
Hot Water Valve HX-3, System side AO	
HX System Diff. Press AI (2)	
HX Flow Station AI (2)	
HX CHWS Temp. AI	

HX CHWR Temp AI
HX HWS Temp. AI
HX HWR Temp AI
Alarms, Status and Energy Data (via BacNet) typ. each pump packages

R. SEQUENCE OF OPERATION - HOT WATER BASEBOARD & PANEL RADIATOR HEAT

1. Space mounted temperature sensors shall enable and disable the radiation valve as required to maintain space temperature setpoint initially set for 62°F during unoccupied periods and 70°F during occupied periods. In areas served by both radiation and air heat, the radiation shall work in conjunction with the air heat with radiation being the first stage of heat followed by the air heat with no more than an adjustable 0.5F dead-band spread.

   Points List

   a. As a minimum, the following points will be monitored and controlled for each segment of radiation. See also points indicated on drawings:

Inputs	Outputs
Space temp. AI	Hot water valve DO
Space temp. adj AI	
Push button override DI	

S. SEQUENCE OF OPERATION – BOILER ROOM VENTILATION & MISC.

1. Whenever the boilers are operating and during all periods the room is occupied as determined by a current sensor on the rooms lighting circuit, the boiler room intake damper shall open (this is not required for combustion air) to allow a passive flow of air into the room, the respective fans need not run. OA damper shall close if room is not occupied and boilers are off.
2. If the room temperature exceeds a space cooling setpoint initially set for 85°F and outdoor air temperature is below room temperature. The intake and exhaust air dampers shall open and intake and exhaust air fans shall modulate speed from 20% to 100% to achieve space cooling setpoint. Once space drops 5°F below cooling setpoint the fans shall be disabled and the dampers closed (OA shall close if
3. Upon a CO alarm, initially set for 30 ppm, an audible and visual alarm shall sound in the area of the plant and a high level alarm shall be reported by the EMS system at the workstation. The intake and exhaust dampers shall open and the intake and exhaust fans shall start and purge the room for 5 minutes after the alarm condition subsides. If the room temperature falls below a setpoint of 45°F the fans shall be disabled and a high level alarm shall be reported by the EMS.
4. DDC Point List – Boiler Room Ventilation

   (1)As a minimum, the following points will be monitored and controlled for the system:

Inputs	Outputs
Exhaust fan status DI	Exhaust fan S/S
Intake fan status DI	Intake fan S/S
Space temp. AI	Fresh Air Damper DO

CO conc. AI (2)	Exhaust damper DO
Lighting current DI	CO Horn/Strobe DO
	Intake Fan Speed AO
	Exhaust Fan Speed AO

T. SEQUENCE OF OPERATION – MUA-1 KITCHEN MAKE-UP AIR UNIT and ASSOC. EXHAUST FANS AND KITCHEN EXHAUST

1. Kitchen Hood Exhaust Fan: Upon a start command from the hood mounted switch, the kitchen hood exhaust fan shall start and run. Proper operation shall be verified by the amperage run indicator.
2. Once the kitchen hood is enabled via the hood system exhaust controller start switch the KEF fan shall start and initially run at a minimum speed setpoint of 40%.
3. The respective kitchen hood KEF fan shall modulate from 40% minimum speed/airflow to its maximum scheduled speed/airflow based on hood smoke & heat detection and control system output. This system shall send status information to the EMS including exhaust air volume for use by the make-up air system control.
4. Dishwasher Hood Exhaust Fan: Upon a start command from a relay to the dishwasher interlock, the dishwash exhaust fan shall start and run. Proper operation shall be verified by the amperage run indicator.
5. MAU-1 Supply Fan Control – Kitchen Hood On Mode
   a. When the main kitchen hood KEF exhaust fan is activated via hood mounted switch, the MAU-1 unit shall be enabled to operate.
   b. OA damper shall open and the supply fan shall modulate as required to match the exhaust air volume minus a 10% offset.
   c. If the hood fan is disabled the MAU shall be disabled and the OA damper shall close.
   d. The space pressure shall be monitored to insure space pressure does not exceed a negative setpoint of -0.01 with respect to the outdoors.
6. Unoccupied (Kitchen Hood Off) Mode

   If the kitchen hood is off the KEF fan shall be disabled. If the kitchen hood system is commanded off or is off due to alarm or the chemical fire agent has discharged, the MAU-1 shall be disabled, its fan and burner disabled, supply fan off and outside air damper closed.

7. Heating & Cooling Control

   When the MAU system is operating the units hot water valve shall vary as required to maintain the discharge and air temperature between 55°F to 70°F reset range based on the space temperature within the kitchen, with supply air being at 55F if kitchen temperature is 75F or above and being at 70F when kitchen temperature is 68 deg. F. or below.

   When outdoor air temperature is below 38 degrees F. the hot water coil valve shall open no less than 25% and the coil shall modulate first and once at 100% open the face and bypass dampers shall modulate to maintain supply air setpoint. When outdoor air temperature is above 38 degrees F., the face and bypass dampers shall be full open to coil flow and the valve shall modulate between 0% and 100% to maintain supply air

setpoint. Face & Bypass and coil valve shall modulate to insure discharge air temperature does not exceed 75 degrees F. (adjustable).

During unoccupied periods when the fans are off the hot water coil valve shall be open 5% subject to a maximum mixed air temperature limit of 70°F.

8. Safeties and Status

   a. The supply air sensor, upon sensing low supply air temperature of below 40°F (after a delay of 60 seconds) shall shut down the MAU-1 unit, O.A. dampers shall close, hot water coil valve shall open 100% and the coil F&B dampers shall close to coil and a freeze alarm shall be generated through the DDC system at the workstation.

   b. Amperage switches installed on the supply and exhaust fan motors shall indicate fan status. If the EMS controller is calling for the fan to be on and the flow switch does not prove, the amperage is too low or not existent, a fan failure alarm shall be sent to the workstation. If the exhaust fan fails the gas valve(s) to equipment under the kitchen hood shall close.

   c. ATC Contractor shall coordinate with Electrical Contractor on direct fan shutdown for duct smoke detection. Duct smoke detectors shall be furnished by the Electrical Contractor. Supply fan shutdown upon activation of duct smoke detector shall be direct wired to fan control circuits from duct detector contacts by the ATC Contractor.

   d. Upon activation of the kitchen hood chemical suppression system, or if the space CO detection system or the natural gas detection system detects a space CO or natural gas level above permissible limit the cooking equipment fuel gas valve shall close. The kitchen hood exhaust fan shall remain operational or if the fan was off it will be enabled on low speed. Coordinate gas valve and control interlock with plumbing contractor and electrical contractor. The kitchen make-up air unit shall be disabled if the kitchen hood suppression system discharges and the outside air damper closed and VAV dampers shall close.

9. DDC Point List

   a. Refer to the plans and these sequences of operation and provide all points required and inferred to make for a fully functional and operation system. Being that the unit shall be BacNet compatible several points may be extracted from the interface however this contractor must provide any points and all points needed to achieve the operation and monitoring level specified. The EMS contractor shall provide all points are units are customized in this regard with the exception of those points integral to the MAU as furnished by the manufacturer. Points in **Bold** are devices supplied by the unit manufacturer. As a minimum the following points being monitored and controlled for each unit:

Inputs	Outputs
Filter Diff. Pressure AI	Supply fan S/S DO
Supply/OA air volume AI	MAU Enable/Disable DO
Duct Static AI	Supply fan VFD AO
Dishwasher Interlock DI (1)	O.A. damper DO

Discharge air temperature AI
Supply fan status
amp. switch DI
Exhaust fan status/
amp. switch DI (2)
Duct Smoke Detector DI

Space temperature AI (2)
Suppression System DI
Kitchen Hood Switch DI (2)
Kitchen MAU VAV Airflow AI (2)
Freezer Temp AI (2)
Cooler Temp AI (2)
Hood Smoke Detection/Control AI
HOOD Smoke & Heat Control BacNet Interface
Hood exhaust air volume AI
Space Pressure AI
Carbon Monoxide (CO)(2 sensors and panel by plumber)
Natural gas detector (2 sensors by plumber)
O.A. temperature AI (global)
O.A. humidity AI (global)

Kitchen MAU VAV AO (2)

MUA-1 Hot Water Coil Valve AO
Face & Bypass Damper AO
Hood Fan Switch with Pilot Light DO
(Kitchen gas valve(s) (by plumber)
Exhaust fan S/S (Hood Fan) DO
Exhaust Fan VFD Hood Fan) AO

V. SEQUENCE OF OPERATION – RTU-1, 2, 3 & 4 DOAS (Chilled Beam Displacement Systems)

1. General

a. RTU-1, 2, 3 & 4 are custom rooftop units with energy recovery wheels units that are variable air volume (VAV) units which provide year round dehumidification, cooling, heating and ventilation to many classroom areas of the building served thru displacement ventilation systems. The units support the following areas:
   - RTU-1: Pod A Classrooms
   - RTU-2: Pod B Classrooms
   - RTU-3: Pod C Classrooms
   - RTU-4: Pod D Classrooms

b. Some limited control sequences and points related to the DX condenser sections shall be accomplished via the units factory condensing unit controls which must be programmed and interfaced to the EMS. The points required to come with the unit are indicated below (in bold) as well as those points the EMS contractor must provide. EMS contractor must coordinate with RTU vendor to insure all specified sequences and points are provided.

2. Supply & Exhaust Fan Control

a. The EMS system shall compare the outdoor conditions, the space conditions and the buildings historical warm-up/cool-down profile to determine the optimum start time required to achieve space setpoint conditions by the scheduled occupied start time. The fans shall run continuous during the occupied time period. During morning warm-up and cool down modes the outdoor air dampers shall remain closed and the system shall supply air reset off of return air temperature as well as

the 3 highest and 3 lowest space temperatures to bring the spaces up to space heating or cooling setpoint. (Refer to Heating Coil Control).

b. The EMS shall index from the occupied mode to the unoccupied mode based on a time schedule furnished by the owner. This schedule may be temporary overridden for a predetermined time period by sensor mounted override switches.

c. For all units with smoke dampers the EMS shall prove that all supply air and return/exhaust air smoke dampers are fully open prior to allowing the fans and unit to operate.

d. The bipolar ionization units shall be enabled at all times the supply fan is enabled and its status shall be monitored.

e. Prior to allowing the unit to operate both the DX coil face dampers shall open 100% and prove open prior to allowing the unit to start. Once enabled and after the fans stabilize (120 seconds adjustable), if the total unit airflow is 50% (adj.) or greater of the total rated airflow as determined by the supply fan airflow station both DX coil face dampers shall be open. If the supply airflow is less than 40% (adj), the unit shall only operate either the upper or lower DX coil circuits and the deactivated coil face damper shall close. Either the lower or upper face damper shall be open and prove open at all times while the unit is in operation. Active upper or lower coil sections shall be rotated in conjunction with the compressor rotation scheme.

3. Occupied Mode

a. At the commencement of occupied mode, the outdoor air damper and exhaust air damper shall open to their respective position with the return/recirculation air dampers going to their respective positions. The supply fan and exhaust fan shall run continuously throughout the occupied time period (see exhaust fan enable herein). If the high limit discharge air duct static sensor meets or exceeds a setpoint of 3”w.c. or the low limit return air duct static sensor meets or exceeds a setpoint of -3” w.c. the unit shall be disabled, fans shall turn off and an alarm shall be reported. The high limit duct static pressure sensor shall be located upstream (unit side) of the supply smoke dampers. The low limit duct static pressure sensor shall be located upstream (unit side) of the return smoke dampers.

b. The supply fan variable frequency drive shall modulate to maintain supply air static pressure setpoint initially set for 0.75”. Every 5 minutes, the system will check all the VAV damper positions and reset static pressure setpoint as follows: If all the VAV damper positions are below a setpoint of 90% open, then decrease the static pressure setpoint by 5% of the design range (initial range of 0.4” minimum and 0.75” maximum for an increment of 0.05”). Otherwise do not change setpoint. If any VAV damper is open greater than a setpoint of 98% then increase the static pressure setpoint by 5% of the design range. Static pressure setpoint shall never exceed the specified static setpoint.

c. The exhaust damper shall open and the exhaust fan variable frequency drive shall modulate the fan speed to maintain exhaust air levels equal to outdoor air levels minus a 5% offset. The exhaust fan shall not start until the outdoor airflow volume exceeds 20% of the scheduled minimum outside air CFM. If the outdoor airflow station is determined during CX testing to not be reliable, the outdoor airflow quantity shall be calculated by using the return duct airflow station and the supply

airflow station with outdoor air equal to supply airflow minus return airflow. Space pressure shall be monitored and a low level alarm reported if space pressure exceeds an initial setpoint of +0.01" with respect to outdoors. When enabled, minimum exhaust fan speed shall not be allowed to fall below a setpoint of 10Hz or as otherwise directed by the unit manufacturer.

d. Outdoor air flow dampers shall maintain outdoor air quantity constant within 10% of the specified outdoor air quantity reset as specified herein.

e. The outdoor air, return air and exhaust dampers shall modulate to maintain the minimum specified outdoor air level as determined by the flow measuring stations. Outdoor air quantity shall be varied between 25% of the specified minimum outdoor air quantity and the specified minimum outdoor air quantity in response to the multiple space CO2 sensors. Dampers shall modulate to maintain a maximum CO2 level at any space sensor of no greater than 800 ppm (adj.) but in no case shall the outdoor air level exceed the scheduled minimum outdoor air value unless economizer cooling is required. Reduced outdoor air CO2 control shall be overridden in the event economizer cooling is required.

f. The energy reclaim wheel shall run continuously during occupied periods however, if outdoor air enthalpy is below return air enthalpy and cooling is required the wheel speed shall modulate to maintain supply air setpoint. Economizer shall be disabled if the OA dry bulb rises above a setpoint of 70F or the OA enthalpy rises above 26 BTU/lb. One the wheel is fully stopped, the wheel bypass dampers shall open.

g. Energy wheel speed shall modulate as frost protection for the wheel insuring that the minimum exhaust air temperature off the wheel does not fall below a setpoint as described below and reset as follows. The final accepted unit and wheel manuf. must be consulted to verify the below values are applicable for their wheel.

RA Humidity	Defrost Enable Outdoor Air Temp	Vary Wheel to Wheel Exhaust Temp
20% RH	-10 F	15 F
30% RH	0 F	20 F
40% RH	10 F	25 F

Pressure drop across wheel in excess of a predefined limit (confirm with factory) shall also indicate a potential frost condition and shall enable defrost mode.

h. If wheel run indicator detects a loss of wheel rotation either due to loss of current or reduced current indicating belt loss an alarm shall be reported by the EMS.

i. Main return air carbon dioxide levels shall be monitored and if levels exceed a maximum CO2 setpoint level of 1,000 ppm (adj.) or greater a low level alarm shall be reported by the EMS.

4. Unoccupied Mode

a. At the commencement of unoccupied mode the outdoor air dampers shall close and the fans shall cycle off. If required, the fans shall cycle on to maintain unoccupied space cooling and heating setpoints initially set for 88°F and 60°F respectively.

b. If the next scheduled occupied period is within the following 24 hours, the units shall operate in unoccupied mode and cycle as needed to maintain the average space dewpoint no higher than a setpoint of 60°F (adj.) so as to not allow the space to become too moist prior to an upcoming occupied mode. See also morning cool-down dry-down mode sequence herein.

5. Cooling/Dehumidification Control

a. The total enthalpy of the return air and outdoor air streams shall be compared and, if advantageous, outdoor air economizer cycle shall be enabled either partially in conjunction with mechanical cooling or exclusively to maintain supply air temperature setpoint. Economizer shall be disabled if the OA dry bulb rises above a setpoint of 65F or the OA enthalpy rises above 25 BTU/lb. In economizer mode, the outdoor air and return air dampers shall modulate as a first stage to satisfy supply air setpoint. The energy reclaim wheel shall run continuously during occupied periods however, if outdoor air enthalpy is below return air enthalpy and cooling is required the wheel speed shall modulate so as to allow the system to reach supply air setpoint as indicated above and herein. If the wheel is fully stopped the bypass dampers shall open to full bypass.

b. If there is a call for space dehumidification as determined by either return air dewpoint or more than 3 space zone sensors detecting a dewpoint above a setpoint of 53°F the DX compressor stages shall stage (inverter compressors shall modulate) to maintain a cooling coil temperature (as measured via refrigerant gas pressure sensor) setpoint of 42 degrees. If gas pressure is not monitored than, the DX cooling coil leaving air temperature shall be set to 48°F. Stages shall increase as the distance and time from setpoint increase with a minimum of 5-minute delay between compressor stages (not inverter stages). Coordinate with delays built into condenser controller. The heat pipe shall control to maintain supply air temperature setpoint followed by hot gas reheat as applicable.

c. Heat Pipe Reheat Valves: The heat pipe reheat valves (4 per coil section- total of 8 stages) shall stage as required to maintain the supply air temperature setpoint during the dehum. cycle.

d. Supply air discharge setpoint shall be reset between 52°F and 65°F based on the average cooling demand from spaces. If more than 3 zones on the system are above cooling setpoint by greater than a setpoint of 3°F, the supply air reset schedule shall reset down towards the minimum overriding the average demand.

e. Morning Cool-Down and Dry-Down: If the average space temperature is above cooling setpoint or if the space humidity is higher than the dehumidification setpoint and it is within 3-hours (adj.) of a scheduled occupied period the EMS shall calculate an optimized start-time to achieve space setpoint and enable the unit into morning cool-down mode. The supply air temperature shall be reset down to 52°F until the average space temperature reaches cooling setpoint or the return air temperature reaches 75°F whichever comes first and the space dewpoint is below the setpoint at which time the unit shall drop out of morning cool-down mode and enter normal occupied operation at the schedule time.

f. If airflow is not proven via a pressure sensor an adjustable differential pressure sensor across either of the DX coil banks, the respective compressors circuits shall

be deactivated without regard for minimum compressor run times (coordinate with compressor controller).

6. Heating Control

   a. The hot water heat valve (if required) shall modulate to maintain the supply air reset schedule initially 52°F to 65°F or no less than 3°F below general space heating setpoint if no spaces require cooling. Maximum supply air temperature reset shall be 65°F. If the outdoor air temperature is below a setpoint of 0°F or the total supply airflow of the unit is less than 30% (confirm with unit manuf.), the heat pump cycle shall be disabled and the unit shall rely on hot water heating. Hot water valve shall be closed if DX cooling or dehumidification mode is operational.

   b. During morning warm-up or cool down the supply air reset schedule shall be overriden and the coil valve shall modulate to satisfy the reset schedule indicated herein.

   c. Morning Warm-up: If the average space temperature is below heating setpoint and it is within 2-hours (adj.) of a scheduled occupied period the units the EMS shall calculate an optimized start-time to achieve space setpoint and enable the unit into morning warm-up mode. The supply air temperature shall be reset up 75°F until the average space temperature reaches heating setpoint or the return air temperature reaches 70°F whichever comes first at which time the unit shall drop out of morning warm-up mode and enter normal occupied operation at the schedule time.

   e. During morning warm-up when outdoor air temperatures are above a setpoint of 0°F, the heat pump cycle shall be the first stage of heat followed by the hot water coil. The intent is to minimize reliance on the fossil fuel hot water boiler plant during these conditions.

   f. During unoccupied periods when outdoor air temperatures are below a setpoint of 38ºF and the unit is off, the hot water coil valves shall modulate to maintain a hot water leaving coil air temperature of 70°F to insure minimum flow through the heating coils and to prevent nuisance trips of the freeze stats.

7. Duct Zone Heating Coil Control

   a. If a group of spaces (VAV zones) on a respective system branch zone with duct hot water coil are overcooling and the RTU unit has reset supply air as high as possible while still maintaining and supporting the overall systems cooling demand, the respective zone hot water heat valve shall modulate to reset that zones supply air between 52°F to 67°F or no less than 3°F below general space heating setpoint. Maximum supply air temperature reset shall be 67°F.

8. System Safeties & Misc.:

   a. The units have glycol in the hot water coils for freeze protection. If the hot water coil freeze stat detects a leaving air temperature below 38°F for longer than 60 seconds, the unit shall report a low temperature alarm but shall not shutdown. If the system discharge air temperature drops below 40°F for longer than 30 seconds, the ATC shall report a freeze condition to the EMS and the following shall occur: Disable supply air and exhaust air fans.

Close the outdoor and exhaust air dampers and open the return air damper.
Open hot water coil valve 100%
Annunciate a local alarm

b. Normal damper positions are as follows:
O.A. damper – normally closed
R.A. damper – normally open
E.A. damper – normally closed

c. Smoke Alarm – Upon a smoke detector activation or if any smoke damper in the system is in a position other than fully open, the unit and fans shall shutdown and the dampers shall go to their normal position (i.e. O.A.-Closed). An alarm shall be reported to the EMS system and the building fire alarm system.

g. The factory condensing unit controller shall perform hot gas reheat coil flush cycles as needed to insure no refrigerant oil is tied up in the coils.

h. Coordinate with factory for minimum on & off times, time delays and such for compressors. The condensing section is a VRF system with branch selector boxes refrigerant valves, etc…. EMS must coordinate fully with integration of the VRF controls with the EMS.

8. DDC Point List – RTU DOAS SYSTEMS

a. Refer to the plans and these sequences of operation and provide all points required and inferred to make for a fully functional and operation system. Being that the units condensing section shall be BacNet compatible several points may be extracted from the interface however this contractor must provide any points and all points needed to achieve the operation and monitoring level specified. The EMS contractor shall provide all points are units are customized in this regard with the exception of those points integral to the RTU condenser section as furnished by the manufacturer. Points in **Bold** are point supplied and/or controlled by the unit manufacturer. Unitary dampers are supplied by the unit manufacturer however, the damper motors and operators are provided by the EMS vendor. As a minimum the following points being monitored and controlled for each unit:

Inputs	Outputs
Filter Diff. Pressure AI	Supply fan S/S DO
Return air volume AI	Exhaust fan S/S DO
Freezestat AI	Supply fan VFD AO
Mixed air temp. AI	O.A. damper AO (mult)
Supply duct static AI	Exhaust damper AO
Supply fan status	RTU Hot Water Coil Valve AO
amp. AI	Exhaust Fan VFD AO
Exhaust fan status/	Wheel Bypass Dampers DO (2)
amp. AI	DX Cooling Stages (multiple) DO & AO
Duct Smoke Det. DI (mult)	Duct Smoke Damper DO (mult) coord. with EC
Discharge air temperature AI	Heat Pipe Stages DO (4 per coil segment)
R.A. temperature AI	Return Air damper AO (mult)
DX Coil Press./Temp AI (mult)	Wheel Enable and Speed DO & AO
R.A. humidity AI	**Supply Fan Array (Bacnet)**
R.A. CO2 AI	**Exhaust Fan Array (Bacnet)**
Space CO2 AI (multiple)	**Condenser section VRF Bacnet Interface**

Wheel discharge air temp AI
Wheel rotation DI
Wheel Pressure Drop AI
Duct Static Pressure AI
High Limit Duct Static DI
Low Limit Duct Static DI
Wheel Supply Leaving Temp AI
Duct Smoke Damper DI (mult)
DX Coil Air DP AI
DX Coil Enterinig Air Temp. AI (mult)
DX Coil Disch. Air Temp. AI (mult)
Coil Damper End Switch DI (mult)
Ionizer Status DI
Supply Air Volume AI
Exhaust Air Volume AI
Zone Hot Water Coil Discharge Air Temp. AI
O.A. temperature AI (global) also integral to unit
O.A. humidity AI (global) also integral to unit
Supply Fan Array Data (Bacnet)
Exhaust Fan Array (Bacnet)
Condenser section Bacnet Interface

DX Coil Face Damper #1 DO (see sch.)
DX Coil Face Damper #2 DO (see sch.)
DX Coil Face Damper #3 DO (see sch.)
Ionizer Enable/Disable DO
Zone Hot Water Coil Valve AO

W. SEQUENCE OF OPERATION – RTU-11 & 18 (Custom VAV Units)

1. General

c. RTU-11 & 18 are custom rooftop units with energy recovery wheels units that are variable air volume (VAV) units which provide year-round dehumidification, cooling, heating and ventilation to the respective areas. The units support the following areas:
   - RTU-11: Lobby
   - RTU-18: Cafeteria

d. Some limited control sequences and points related to the DX condenser sections shall be accomplished via the units factory condensing unit controls which must be programmed and interfaced to the EMS. The points required to come with the unit are indicated below (in bold) as well as those points the EMS contractor must provide. EMS contractor must coordinate with RTU vendor to ensure all specified sequences and points are provided.

2. Supply & Exhaust Fan Control

a. The EMS system shall compare the outdoor conditions, the space conditions and the buildings historical warm-up/cool-down profile to determine the optimum start time required to achieve space setpoint conditions by the scheduled occupied start time. The fans shall run continuous during the occupied time period. During morning warm-up and cool down modes the outdoor air dampers shall remain closed and the system shall supply air reset off of return air temperature as well as the 3 highest and 3 lowest space temperatures to bring the spaces up to space heating or cooling setpoint. (Refer to Heating Coil Control).

b. The EMS shall index from the occupied mode to the unoccupied mode based on a time schedule furnished by the owner. This schedule may be temporary overridden for a predetermined time period by sensor mounted override switches.

c. For all units with smoke dampers the EMS shall prove that all supply air and return/exhaust air smoke dampers are fully open prior to allowing the fans and unit to operate.

d. The bipolar ionization units shall be enabled at all times the supply fan is enabled and its status shall be monitored.

e. Prior to allowing the unit to operate both the DX coil face dampers shall open 100% and prove open prior to allowing the unit to start. Once enabled and after the fans stabilize (120 seconds adjustable), if the total unit airflow is 50% (adj.) or greater of the total rated airflow as determined by the supply fan airflow station both DX coil face dampers shall be open. If the supply airflow is less than 40% (adj), the unit shall only operate either the upper or lower DX coil circuits and the deactivated coil face damper shall close. Either the lower or upper face damper shall be open and prove open at all times while the unit is in operation. Active upper or lower coil sections shall be rotated in conjunction with the compressor rotation scheme.

f. The ASF-# fans shall start and run continuously until all heating demand for the served space has ended. ASF fans shall be enabled as a 1st stage call for heat. If the outdoor air temperature is below a setpoint of 40°F the ASF fans shall run continuously regardless of occupancy mode. User shall be able to control the speed of these fans by adjusting at the front-end

3. Occupied Mode

a. At the commencement of occupied mode, the outdoor air damper and exhaust air damper shall open to their respective position with the return/recirculation air dampers going to their respective positions. The supply fan and exhaust fan shall run continuously throughout the occupied time period (see exhaust fan enable herein). If the high limit discharge air duct static sensor meets or exceeds a setpoint of 3”w.c. or the low limit return air duct static sensor meets or exceeds a setpoint of -3” w.c. the unit shall be disabled, fans shall turn off and an alarm shall be reported. The high limit duct static pressure sensor shall be located upstream (unit side) of the supply smoke dampers. The low limit duct static pressure sensor shall be located upstream (unit side) of the return smoke dampers.

b. The supply fan variable frequency drive shall modulate to maintain supply air static pressure setpoint initially set for 0.75”. Every 5 minutes, the system will check all the VAV damper positions and reset static pressure setpoint as follows: If all the VAV damper positions are below a setpoint of 90% open, then decrease the static pressure setpoint by 5% of the design range (initial range of 0.4” minimum and 0.75” maximum for an increment of 0.05”). Otherwise do not change setpoint. If any VAV damper is open greater than a setpoint of 98% then increase the static pressure setpoint by 5% of the design range. Static pressure setpoint shall never exceed the specified static setpoint.

c. The exhaust damper shall open and the exhaust fan variable frequency drive shall modulate the fan speed to maintain exhaust air levels equal to outdoor air levels minus a 5% offset. The exhaust fan shall not start until the outdoor airflow volume

exceeds 20% of the scheduled minimum outside air CFM. If the outdoor airflow station is determined during CX testing to not be reliable, the outdoor airflow quantity shall be calculated by using the return duct airflow station and the supply airflow station with outdoor air equal to supply airflow minus return airflow. Space pressure shall be monitored and a low level alarm reported if space pressure exceeds an initial setpoint of +0.01" with respect to outdoors. When enabled, minimum exhaust fan speed shall not be allowed to fall below a setpoint of 10Hz or as otherwise directed by the unit manufacturer.

d. Outdoor air flow dampers shall maintain outdoor air quantity constant within 10% of the specified outdoor air quantity reset as specified herein.

e. The outdoor air, return air and exhaust dampers shall modulate to maintain the minimum specified outdoor air level as determined by the flow measuring stations. Outdoor air quantity shall be varied between 25% of the specified minimum outdoor air quantity and the specified minimum outdoor air quantity in response to the multiple space CO2 sensors. Dampers shall modulate to maintain a maximum CO2 level at any space sensor of no greater than 800 ppm (adj.) but in no case shall the outdoor air level exceed the scheduled minimum outdoor air value unless economizer cooling is required. Reduced outdoor air CO2 control shall be overridden in the event economizer cooling is required.

f. The energy reclaim wheel shall run continuously during occupied periods however, if outdoor air enthalpy is below return air enthalpy and cooling is required the wheel speed shall modulate to maintain supply air setpoint. Economizer shall be disabled if the OA dry bulb rises above a setpoint of 70F or the OA enthalpy rises above 26 BTU/lb. One the wheel is fully stopped, the wheel bypass dampers shall open.

g. Energy wheel speed shall modulate as frost protection for the wheel insuring that the minimum exhaust air temperature off the wheel does not fall below a setpoint as described below and reset as follows. The final accepted unit and wheel manuf. must be consulted to verify the below values are applicable for their wheel.

RA Humidity	Defrost Enable Outdoor Air Temp	Vary Wheel to Wheel Exhaust Temp
20% RH	-10 F	15 F
30% RH	0 F	20 F
40% RH	10 F	25 F

Pressure drop across wheel in excess of a predefined limit (confirm with factory) shall also indicate a potential frost condition and shall enable defrost mode.

h. If wheel run indicator detects a loss of wheel rotation either due to loss of current or reduced current indicating belt loss an alarm shall be reported by the EMS.

i. Main return air carbon dioxide levels shall be monitored and if levels exceed a maximum CO2 setpoint level of 1,000 ppm (adj.) or greater a low level alarm shall be reported by the EMS.

4. Unoccupied Mode

a. At the commencement of unoccupied mode the outdoor air dampers shall close and the fans shall cycle off. If required, the fans shall cycle on to maintain unoccupied space cooling and heating setpoints initially set for 88°F and 60°F respectively.

b. If the next scheduled occupied period is within the following 24 hours, the units shall operate in unoccupied mode and cycle as needed to maintain the average space dewpoint no higher than a setpoint of 60°F (adj.) so as to not allow the space to become too moist prior to an upcoming occupied mode. See also morning cool-down dry-down mode sequence herein.

5. Cooling/Dehumidification Control

a. The total enthalpy of the return air and outdoor air streams shall be compared and, if advantageous, outdoor air economizer cycle shall be enabled either partially in conjunction with mechanical cooling or exclusively to maintain supply air temperature setpoint. Economizer shall be disabled if the OA dry bulb rises above a setpoint of 65F or the OA enthalpy rises above 25 BTU/lb. In economizer mode, the outdoor air and return air dampers shall modulate as a first stage to satisfy supply air setpoint. The energy reclaim wheel shall run continuously during occupied periods however, if outdoor air enthalpy is below return air enthalpy and cooling is required the wheel speed shall modulate so as to allow the system to reach supply air setpoint as indicated above and herein. If the wheel is fully stopped the bypass dampers shall open to full bypass.

b. If there is a call for space dehumidification as determined by return air dewpoint or if the OA dewpoint or supply air dewpoint rises above a setpoint of 53°F the DX compressor stages shall stage (inverter compressors shall modulate) to maintain a cooling coil temperature (as measured via refrigerant gas pressure sensor) setpoint of 42 degrees. If gas pressure is not monitored than, the DX cooling coil leaving air temperature shall be set to 48°F. Stages shall increase as the distance and time from setpoint increase with a minimum of 5-minute delay between compressor stages (not inverter stages). Coordinate with delays built into condenser controller. The heat pipe shall control to maintain supply air temperature setpoint followed by hot gas reheat as applicable.

i. Heat Pipe Reheat Valves: The heat pipe reheat valves (4 per coil section- total of 8 stages) shall stage as required to maintain the supply air temperature setpoint during the dehum. cycle.

j. Supply air discharge setpoint shall be reset between 55°F and 65°F based on the average cooling demand from spaces. If more than 3 zones on the system are above cooling setpoint by greater than a setpoint of 3°F, the supply air reset schedule shall reset down towards the minimum overriding the average demand.

k. Morning Cool-Down and Dry-Down: If the average space temperature is above cooling setpoint or if the space humidity is higher than the dehumidification setpoint and it is within 3-hours (adj.) of a scheduled occupied period the EMS shall calculate an optimized start-time to achieve space setpoint and enable the unit into morning cool-down mode. The supply air temperature shall be reset down to 52°F until the average space temperature reaches cooling setpoint or the return air temperature reaches 75°F whichever comes first and the space dewpoint is below the setpoint at which time the unit shall drop out of morning cool-down mode and enter normal occupied operation at the schedule time.

l. If airflow is not proven via a pressure sensor an adjustable differential pressure sensor across either of the DX coil banks, the respective compressors circuits shall be deactivated without regard for minimum compressor run times (coordinate with compressor controller).

6. Heating Control

a. The hot water heat valve (if required) shall modulate to maintain the supply air reset schedule initially 52°F to 68°F or no less than 3°F below general space heating setpoint if no spaces require cooling. Maximum supply air temperature reset shall be 65°F. If the outdoor air temperature is below a setpoint of 0°F or the total supply airflow of the unit is less than 30% (confirm with unit manuf.), the heat pump cycle shall be disabled and the unit shall rely on hot water heating. Hot water valve shall be closed if DX cooling or dehumidification mode is operational.

b. During morning warm-up or cool down the supply air reset schedule shall be overriden and the coil valve shall modulate to satisfy the reset schedule indicated herein.

c. Morning Warm-up: If the average space temperature is below heating setpoint and it is within 2-hours (adj.) of a scheduled occupied period the units the EMS shall calculate an optimized start-time to achieve space setpoint and enable the unit into morning warm-up mode. The supply air temperature shall be reset up 75°F until the average space temperature reaches heating setpoint or the return air temperature reaches 70°F whichever comes first at which time the unit shall drop out of morning warm-up mode and enter normal occupied operation at the schedule time.

g. During morning warm-up when outdoor air temperatures are above a setpoint of 0°F, the heat pump cycle shall be the first stage of heat followed by the hot water coil. The intent is to minimize reliance on the fossil fuel hot water boiler plant during these conditions.

h. During unoccupied periods when outdoor air temperatures are below a setpoint of 38ºF and the unit is off, the hot water coil valves shall modulate to maintain a hot water leaving coil air temperature of 70°F to ensure minimum flow through the heating coils and to prevent nuisance trips of the freeze stats.

7. System Safeties & Misc.:

a. The units have glycol in the hot water coils for freeze protection. If the hot water coil freeze stat detects a leaving air temperature below 38°F for longer than 60 seconds, the unit shall report a low temperature alarm but shall not shutdown. If the system discharge air temperature drops below 40°F for longer than 30 seconds, the ATC shall report a freeze condition to the EMS and the following shall occur:
Disable supply air and exhaust air fans.
Close the outdoor and exhaust air dampers and open the return air damper.
Open hot water coil valve 100%
Annunciate a local alarm

b. Normal damper positions are as follows:
O.A. damper – normally closed

R.A. damper – normally open
E.A. damper – normally closed

c. Smoke Alarm – Upon a smoke detector activation or if any smoke damper in the system is in a position other than fully open, the unit and fans shall shutdown and the dampers shall go to their normal position (i.e. O.A.-Closed). An alarm shall be reported to the EMS system and the building fire alarm system.

m. The factory condensing unit controller shall perform hot gas reheat coil flush cycles as needed to insure no refrigerant oil is tied up in the coils.

n. Coordinate with factory for minimum on & off times, time delays and such for compressors. The condensing section is a VRF system with branch selector boxes refrigerant valves, etc…. EMS must coordinate fully with integration of the VRF controls with the EMS.

8. DDC Point List – RTU-11 & 18 SYSTEMS

a. Refer to the plans and these sequences of operation and provide all points required and inferred to make for a fully functional and operation system. Being that the units condensing section shall be BacNet compatible several points may be extracted from the interface however this contractor must provide any points and all points needed to achieve the operation and monitoring level specified. The EMS contractor shall provide all points are units are customized in this regard with the exception of those points integral to the RTU condenser section as furnished by the manufacturer. Points in **Bold** are point supplied and/or controlled by the unit manufacturer. Unitary dampers are supplied by the unit manufacturer however, the damper motors and operators are provided by the EMS vendor. As a minimum the following points being monitored and controlled for each unit:

Inputs	Outputs
Filter Diff. Pressure AI	Supply fan S/S DO
Return air volume AI	Exhaust fan S/S DO
Freezestat AI	Supply fan VFD AO
Mixed air temp. AI	O.A. damper AO (mult)
Supply duct static AI	Exhaust damper AO
Supply fan status	RTU Hot Water Coil Valve AO
amp. AI	Exhaust Fan VFD AO
Exhaust fan status/	Wheel Bypass Dampers DO (2)
amp. AI	DX Cooling Stages (multiple) DO & AO
Duct Smoke Det. DI (mult)	Duct Smoke Damper DO (mult) coord. with EC
Discharge air temperature AI	Heat Pipe Stages DO (4 per coil segment)
R.A. temperature AI	Return Air damper AO (mult)
DX Coil Press./Temp AI (mult)	Wheel Enable and Speed DO & AO
R.A. humidity AI	**Supply Fan Array (Bacnet)**
R.A. CO2 AI	**Exhaust Fan Array (Bacnet)**
Space CO2 AI (multiple)	**Condenser section VRF Bacnet Interface**
Wheel discharge air temp AI	DX Coil Face Damper #1 DO (see sch.)
Wheel rotation DI	DX Coil Face Damper #2 DO (see sch.)
Wheel Pressure Drop AI	Ionizer Enable/Disable DO
Duct Static Pressure AI	
High Limit Duct Static DI	
Low Limit Duct Static DI	

Wheel Supply Leaving Temp AI
Duct Smoke Damper DI (mult)
DX Coil Air DP AI
DX Coil Enterinig Air Temp. AI (mult)
DX Coil Disch. Air Temp. AI (mult)
Coil Damper End Switch DI (mult)
Ionizer Status DI
Supply Air Volume AI
Exhaust Air Volume AI
Zone Hot Water Coil Discharge Air Temp. AI
O.A. temperature AI (global) also integral to unit
O.A. humidity AI (global) also integral to unit
Supply Fan Array Data (Bacnet)
Exhaust Fan Array (Bacnet)
Condenser section Bacnet Interface

X. SEQUENCE OF OPERATION – RTU-6, 7, 8, 10, 14, 16, 17, 20, 23 (VAV Systems)

1. General

a. RTU-6, 7, 9, 10, 14, 16, 17, 20, 23 are packaged rooftop units with energy recovery wheels units that are variable air volume (VAV) units which provide year round dehumidification, cooling, heating and ventilation to various areas of the building. The units support the following areas:
   - RTU-6: Corridor A
   - RTU-7: Chorus & Band
   - RTU-8 Blackbox Theatre
   - RTU-10: Office, Nurse DOAS
   - RTU-14: Corridor B
   - RTU-16: Media Center
   - RTU-17: Kitchen/Servery
   - RTU-20: Corridor CD
   - RTU-23: Wellness

b. Some limited control sequences and points related to the DX condenser sections shall be accomplished via the units factory condensing unit controls which must be programmed and interfaced to the EMS. The points required to come with the unit are indicated below (in bold) as well as those points the EMS contractor must provide. EMS contractor must coordinate with RTU vendor to insure all specified sequences and points are provided.

2. Supply & Exhaust Fan Control

a. The EMS system shall compare the outdoor conditions, the space conditions and the buildings historical warm-up/cool-down profile to determine the optimum start time required to achieve space setpoint conditions by the scheduled occupied start time. The fans shall run continuous during the occupied time period. During morning warm-up mode the outdoor air dampers shall remain closed and the system shall supply air reset off the return air temperature to bring the spaces up to space heating setpoint (Refer to Heating Coil Control).

b. The EMS shall index from the occupied mode to the unoccupied mode based on a time schedule furnished by the owner. This schedule may be temporary overridden for a predetermined time period by sensor mounted override switches.

c. For all units with smoke dampers the EMS shall prove that all supply air and return/exhaust air smoke dampers are fully open prior to allowing the fans and unit to operate.

d. The bipolar ionization units shall be enabled at all times the supply fan is enabled and its status shall be monitored.

e. On systems with respective anti-stratification fans ASF-# fans shall start and run continuously until all heating demand for the served space has ended. ASF fans shall be enabled as a 1st stage call for heat. If the outdoor air temperature is below a setpoint of 40°F the ASF fans shall run continuously regardless of occupancy mode. User shall be able to control the speed of these fans by adjusting at the front-end.

3. Occupied Mode

a. At the commencement of occupied mode, the outdoor air damper shall open to its respective position with the return/recirculation air dampers going to their respective positions. The supply fan and exhaust fan shall run continuously throughout the occupied time period (see exhaust fan enable herein). If the high limit discharge air duct static sensor meets or exceeds a setpoint of 3”w.c. or the low limit return air duct static sensor meets or exceeds a setpoint of -3” w.c. the unit shall be disabled, fans shall turn off and an alarm shall be reported. The high limit duct static pressure sensor shall be located upstream (unit side) of the supply smoke dampers. The low limit duct static pressure sensor shall be located upstream (unit side) of the return smoke dampers.

b. The supply fan variable frequency drive shall modulate to maintain supply air static pressure setpoint initially set for 0.75”. Every 5 minutes, the system will check all the VAV damper positions and reset static pressure setpoint as follows: If all the VAV damper positions are below a setpoint of 90% open, then decrease the static pressure setpoint by 5% of the design range (initial range of 0.4” minimum and 0.75” maximum for an increment of 0.05”). Otherwise do not change setpoint. If any VAV damper is open greater than a setpoint of 98% then increase the static pressure setpoint by 5% of the design range. Static pressure setpoint shall never exceed the specified static setpoint

c. The exhaust fan variable frequency drive shall modulate the fan speed to maintain exhaust air levels equal to outdoor air levels minus an predefined offset. The exhaust damper shall open (gravity style) when the fan is enabled. For all but RTU-11, the exhaust fan shall not start until the outdoor airflow volume exceeds 25% of the scheduled minimum OA CFM. If the outdoor airflow station is determined during CX testing to not be reliable, the outdoor airflow quantity shall be calculated by using the return duct airflow station and the supply airflow station with outdoor air equal to supply airflow minus return airflow Space pressure shall be monitored and a low level alarm reported if space pressure exceeds an initial setpoint of +0.01” with respect to outdoors. When enabled, minimum exhaust fan speed shall not be allowed to fall below a setpoint of 10Hz or as otherwise directed by the unit manufacturer.

d. Outdoor air flow dampers shall maintain outdoor air quantity constant within 10% of the specified outdoor air quantity reset as specified herein.

e. The outdoor air, return air and exhaust dampers shall modulate to maintain the minimum specified outdoor air level as determined by the flow measuring stations. Outdoor air quantity shall be varied between 25% of the specified minimum outdoor air quantity and the specified minimum outdoor air quantity in response to the multiple space CO2 sensors, where shown on the plans, or the return air sensor, if space sensors are not identified. For all but RTU-10 DOAS units, dampers shall modulate to maintain a maximum CO2 level at any space sensor of no greater than 800 ppm (adj.) but in no case shall the outdoor air level exceed the scheduled minimum outdoor air value unless economizer cooling is required. Reduced outdoor air CO2 control shall be overridden in the event economizer cooling is required. RTU-10 is a 100% OA unit and OA shall vary based on the variation in supply air volume.

f. The energy reclaim wheel shall run continuously during occupied periods however, if outdoor air enthalpy is below return air enthalpy and cooling is required the wheel speed shall modulate to maintain supply air setpoint. Economizer shall be disabled if the OA dry bulb rises above a setpoint of 70F or the OA enthalpy rises above 26 BTU/lb. One the wheel is fully stopped, the wheel bypass dampers shall open.

g. Energy wheel speed shall modulate as frost protection for the wheel insuring that the minimum exhaust air temperature off the wheel does not fall below a setpoint as described below and reset as follows. The final accepted unit and wheel manuf. must be consulted to verify the below values are applicable for their wheel.

RA Humidity	Defrost Enable Outdoor Air Temp	Vary Wheel to Wheel Exhaust Temp
20% RH	-10 F	15 F
30% RH	0 F	20 F
40% RH	10 F	25 F

Pressure drop across wheel in excess of a predefined limit (confirm with factory) shall also indicate a potential frost condition and shall enable defrost mode.

h. If wheel run indicator detects a loss of wheel rotation either due to loss of current or reduced current indicating belt loss an alarm shall be reported by the EMS.

i. Main return air carbon dioxide levels shall be monitored and if levels exceed a maximum CO2 setpoint level of 800 ppm (adj.) or greater a low level alarm shall be reported by the EMS.

4. Unoccupied Mode

a. At the commencement of unoccupied mode the outdoor air dampers shall close and the fans shall cycle off. If required, the fans shall cycle on to maintain unoccupied space cooling and heating setpoints initially set for 88°F and 60°F respectively.

b. If the next scheduled occupied period is within the following 24 hours, the units shall operate in unoccupied mode and cycle as needed to maintain the average space dewpoint no higher than a setpoint of 60°F (adj.) so as to not allow the space to

become too moist prior to an upcoming occupied mode. See also morning cool-down dry-down mode sequence herein

5. Cooling/Dehumidification Control

   a. The total enthalpy of the return air and outdoor air streams shall be compared and, if advantageous, outdoor air economizer cycle shall be enabled either partially in conjunction with mechanical cooling or exclusively to maintain supply air temperature setpoint. Economizer shall be disabled if the OA dry bulb rises above a setpoint of 70F or the OA enthalpy rises above 26 BTU/lb. In economizer mode, the outdoor air and return air dampers shall modulate as a first stage to satisfy supply air setpoint. The energy reclaim wheel shall run continuously during occupied periods however, if outdoor air enthalpy is below return air enthalpy and cooling is required the wheel speed shall modulate so as to allow the system to reach supply air setpoint as indicated above and herein. If the wheel is fully stopped the bypass dampers shall open to full bypass.

   b. If there is a call for space dehumidification as determined by return air dewpoint rising above a setpoint of 55°F the DX compressor stages shall stage (inverter compressor shall modulate) to maintain a cooling coil temperature (as measured via refrigerant gas pressure sensor) setpoint of 45 degrees. If suction temp is not monitored than the leaving air temp. of the cooling coil shall be set to 53°F. Stages shall increase as the distance and time from setpoint increase with a minimum of 5-minute delay between compressor stages (not inverter modulation). Coordinate with delays built into condenser controller. Hot gas reheat shall be modulated as required to maintain supply air setpoint.

   c. Hot Gas Reheat Valve (HGRV) Purge Cycle: When the hot gas reheat valve has not been open for at least 2 consecutive minutes within the last hour and a compressor is running in the reheat circuit, the hot gas reheat purge cycle shall be enabled and the HGRV shall be forced 100% open for an adjustable purge duration of 2 minutes. The purge cycle may occur once every 60 minutes (adj.).

   d. Supply air discharge setpoint shall be reset between 55°F and 65°F based on an average of the cooling demand from spaces. If more than 3 zones on the system are above cooling setpoint by greater than a setpoint of 3°F, the supply air reset schedule shall reset down towards the minimum overriding the average demand.

   e. On the RTU-10 DOAS unit, supply air discharge setpoint shall be reset between 65°F and 70°F based on an average of the cooling demand from spaces. If more than 3 zones on the system are above cooling setpoint by greater than a setpoint of 3°F, the supply air reset schedule shall reset down towards the minimum overriding the average demand.

   f. Morning Cool-Down: If the average space temperature is above cooling setpoint and it is within 2-hours (adj.) of a scheduled occupied period the EMS shall calculate an optimized start-time to achieve space setpoint and enable the unit into morning cool-down mode. The supply air temperature shall be reset down to 55°F until the average space temperature reaches cooling setpoint or the return air temperature reaches 75°F whichever comes first at which time the unit shall drop out of morning cool-down mode and enter normal occupied operation at the schedule time.

g. If airflow is not proven via a pressure sensor an adjustable differential pressure sensor across the DX coil, the compressors circuits shall be deactivated without regard for minimum compressor run times (coordinate with compressor controller).

6. Heating Control

a. The hot water heat valve shall modulate if required to maintain the supply air reset schedule as identified in the cooling sequence initially 55°F to 65°F. Hot water valve shall be closed if DX cooling or dehumidification mode is operational.

b. During morning warm-up or cool down the supply air reset schedule shall be overriden and the coil valve shall modulate to satisfy the reset schedule indicated herein.

c. Morning Warm-up: If the average space temperature is below heating setpoint and it is within 2-hours (adj.) of a scheduled occupied period the units the EMS shall calculate an optimized start-time to achieve space setpoint and enable the unit into morning warm-up mode. The supply air temperature shall be reset up 90°F until the average space temperature reaches heating setpoint or the return air temperature reaches 70°F whichever comes first at which time the unit shall drop out of morning warm-up mode and enter normal occupied operation at the schedule time

d. During morning warm-up or during any unoccupied period when outdoor air temperatures are above a setpoint of 15°F, the RTU heat pump cycle shall be the first stage of heat followed by the hot water coils and space radiation. The intent is to minimize reliance on the fossil fuel hot water boiler plant during these conditions.

e. During unoccupied periods when outdoor air temperatures are below a setpoint of 38ºF and the unit is off, the hot water coil valves shall modulate to maintain a hot water leaving coil air temperature of 70°F to insure minimum flow through the heating coils and to prevent nuisance trips of the freeze stats.

7. System Safeties & Misc.:

a. The units have glycol in the hot water coils for freeze protection. If the hot water coil freeze stat detects a leaving air temperature below 38°F for longer than 60 seconds, the unit shall report a low temperature alarm but shall not shutdown. If the system discharge air temperature drops below 40°F for longer than 30 seconds, the ATC shall report a freeze condition to the EMS and the following shall occur:
Disable supply air and exhaust air fans.
Close the outdoor and exhaust air dampers and open the return air damper.
Open hot water coil valve 100%
Annunciate a local alarm

b. Normal damper positions are as follows:
O.A. damper – normally closed
R.A. damper – normally open
E.A. damper – normally closed

c. Smoke Alarm – Upon a smoke detector activation or if any smoke damper in the system is in a position other than fully open, the unit and fans shall shutdown and

the dampers shall go to their normal position (i.e. O.A.-Closed). An alarm shall be reported to the EMS system and the building fire alarm system.

d. The factory condensing unit controller shall perform hot gas reheat coil flush cycles as needed to insure no refrigerant oil is tied up in the coils.

e. Coordinate with factory for minimum on & off times, time delays and such for compressors.

8. DDC Point List – RTU- 6, 7, 9, 10, 14, 16, 17, 20, 23

a. Refer to the plans and these sequences of operation and provide all points required and inferred to make for a fully functional and operation system. Being that the units condensing section shall be BacNet compatible several points may be extracted from the interface however this contractor must provide any points and all points needed to achieve the operation and monitoring level specified. The EMS contractor shall provide all points are units are customized in this regard with the exception of those points integral to the RTU condenser section as furnished by the manufacturer. Points in **Bold** are point supplied and/or controlled by the unit manufacturer. Refer to respective equipment section in specification for devices being supplied by factory but still required to be controlled by EMS. Unitary dampers are supplied by the unit manufacturer however, the damper motors and operators are provided by the EMS vendor. As a minimum the following points being monitored and controlled for each unit:

Inputs	Outputs
Filter Diff. Pressure AI (3)	Supply fan S/S DO
Return air volume AI	Exhaust fan S/S DO
Freezestat AI	Supply fan VFD AO
Mixed air temp. AI	O.A. damper AO
Supply duct static AI	Return/recirc Air damper AO
Supply fan status	Hot Water Coil Valve AO
amp. AI	Exhaust Fan VFD AO
Exhaust fan status/	Wheel Bypass Dampers DO (2)
amp. AI	DX Cooling Stages (multiple) DO & AO
Duct Smoke Det. DI (mult)	DX Heat Stages (mult) DO&AO
Discharge air temperature AI	**Hot Gas Reheat Valves AO (multiple)**
R.A. temperature AI	Wheel Enable and Speed DO & AO
DX Coil Press./Temp AI (mult)	Duct Smoke Damper DO (mult) coord. with EC
R.A. humidity AI	**Condenser section Bacnet Interface**
R.A. CO2 AI	Anti-Stratification Fans AO
Space CO2 AI (multiple)	Ionizer enable/disable DO
Wheel exhaust leaving air temp AI	
Wheel rotation DI	
Wheel Pressure Drop AI	
Duct Static Pressure AI	
High Limit Duct Static DI (RTU-11 only)	
Low Limit Duct Static DI (RTU-11 only)	
Wheel Supply Leaving Temp AI	
DX Coil Air DP AI	
Duct Smoke Damper DI (RTU-11 only)	
Ionizer status DI	
Factory Discharge air Sensor	

Supply Air Volume AI
Exhaust Air Volume AI
Outdoor Air Volume AI
Factory OA temp. sensor
O.A. temperature AI (global) also integral to unit
O.A. humidity AI (global) also integral to unit
Condenser section Bacnet Interface

Note: OA, RA and Bypass damper actuators as well as wheel rotation sensor are furnished with units but must be wired and controlled by EMS. Freezestat is furnished and installed by unit manufacturer but must be wired from terminal strip to EMS.

Y. SEQUENCE OF OPERATION – RTU-5, 9, 15, 19, 24 (VAV Systems with EA VAV)

1. General

a. RTU-5, 9, 15, 19 & 24 are packaged rooftop units with energy recovery wheels units that are variable air volume (VAV) units which provide year-round dehumidification, cooling, heating and ventilation to areas in the building. The units support the following areas:
- RTU-5: Pod A Science DOAS
- RTU-9: ETA Shops DOAS
- RTU-15: Art Rooms DOAS
- RTU-19: Pod A Science DOAS
- RTU-24 Locker Room

b. Some limited control sequences and points related to the DX condenser sections shall be accomplished via the units factory condensing unit controls which must be programmed and interfaced to the EMS. The points required to come with the unit are indicated below (in bold) as well as those points the EMS contractor must provide. EMS contractor must coordinate with RTU vendor to ensure all specified sequences and points are provided.

2. Supply & Exhaust Fan Control

a. The EMS system shall compare the outdoor conditions, the space conditions and the buildings historical warm-up/cool-down profile to determine the optimum start time required to achieve space setpoint conditions by the scheduled occupied start time. The fans shall run continuous during the occupied time period. During morning warm-up mode the outdoor air dampers shall remain closed and the system shall supply air reset off the return air temperature to bring the spaces up to space heating setpoint (Refer to Heating Coil Control).

b. The EMS shall index from the occupied mode to the unoccupied mode based on a time schedule furnished by the owner. This schedule may be temporary overridden for a predetermined time period by sensor mounted override switches.

c. For all units with smoke dampers the EMS shall prove that all supply air and return/exhaust air smoke dampers are fully open prior to allowing the fans and unit to operate.

d. The bipolar ionization units shall be enabled at all times the supply fan is enabled and its status shall be monitored.

e. Science RTU's provide make-up air for the science room fume hoods and the ETA suite local exhausts as well as the CCL AHU-1 provides make-up air for the local welding booths. If the fume hoods are enabled or the welding booth exhaust fan is enabled the respective RTU shall be enabled to support the make-up air regardless of occupied schedule.

3. Occupied Mode

a. At the commencement of occupied mode, the outdoor air damper shall open 100% and the return/recirculation air dampers shall close. The supply fan and exhaust fan shall run continuously throughout the occupied time period (see exhaust fan enable herein). If discharge air duct static rises above a setpoint of 3"w.c. the unit shall be disabled and an alarm shall be reported. The high limit duct static pressure sensor shall be located upstream (unit side) of the smoke dampers.

b. The supply fan variable frequency drive shall modulate to maintain supply air static pressure setpoint initially set for 0.75". Every 5 minutes, the system will check all the VAV damper positions and reset static pressure setpoint as follows: If all the VAV damper positions are below a setpoint of 90% open, then decrease the static pressure setpoint by 5% of the design range (initial range of 0.4" minimum and 0.75" maximum for an increment of 0.05"). Otherwise do not change setpoint. If any VAV damper is open greater than a setpoint of 98% then increase the static pressure setpoint by 5% of the design range. Static pressure setpoint shall never exceed the specified static setpoint.

c. The exhaust fan variable frequency drive to maintain return/exhaust air static pressure setpoint initially set for -0.75". The exhaust air damper shall open (gravity style) when the fan is enabled. Refer to VAV Terminal Sequence for additional information. Every 5 minutes, the system will check all the VAV damper positions and reset static pressure setpoint as follows: If all the VAV damper positions are below a setpoint of 90% open, then decrease the static pressure setpoint by 5% of the design range (initial range of -0.4" minimum and -0.75" maximum for an increment of 0.05"). Otherwise do not change setpoint. If any VAV damper is open greater than a setpoint of 98% then increase the static pressure setpoint by 5% of the design range. Static pressure setpoint shall never exceed the specified static setpoint.

d. When enabled, minimum exhaust fan speed shall not be allowed to fall below a setpoint of 10Hz or as otherwise directed by the unit manufacturer.

e. Outdoor air flow as determined by the supply airflow (as unit is 100% OA) shall be monitored.

f. The energy reclaim wheel shall run continuously during occupied periods however, if outdoor air enthalpy is below return air enthalpy and cooling is required the wheel speed shall modulate to maintain supply air setpoint. Economizer shall be disabled if the OA dry bulb rises above a setpoint of 70F or the OA enthalpy rises above 26 BTU/lb. One the wheel is fully stopped, the wheel bypass dampers shall open.

g. Energy wheel speed shall modulate as frost protection for the wheel insuring that the minimum exhaust air temperature off the wheel does not fall below a setpoint as described below and reset as follows. The final accepted unit and wheel manuf. must be consulted to verify the below values are applicable for their wheel.

RA Humidity	Defrost Enable Outdoor Air Temp	Vary Wheel to Wheel Exhaust Temp
20% RH	-10 F	15 F
30% RH	0 F	20 F
40% RH	10 F	25 F

Pressure drop across wheel in excess of a predefined limit (confirm with factory) shall also indicate a potential frost condition and shall enable defrost mode.

h. If wheel run indicator detects a loss of wheel rotation either due to loss of current or reduced current indicating belt loss an alarm shall be reported by the EMS.

i. Main return air carbon dioxide levels shall be monitored and if levels exceed a maximum CO2 setpoint level of 800 ppm (adj.) or greater a low level alarm shall be reported by the EMS.

4. Unoccupied Mode

a. At the commencement of unoccupied mode the outdoor air dampers shall close and the fans shall cycle off. If required, the fans shall cycle on to maintain unoccupied space cooling and heating setpoints initially set for 88°F and 60°F respectively.

b. For RTU-5, 9, 15 & 19, If the next scheduled occupied period is within the following 24 hours, the units shall operate in unoccupied mode and cycle as needed to maintain the average space dewpoint no higher than a setpoint of 60°F so as to not allow the space to become too moist prior to an upcoming occupied mode. See also morning cool-down dry-down mode sequence herein.

5. Cooling/Dehumidification Control

a. The total enthalpy of the return air and outdoor air streams shall be compared and, if advantageous, outdoor air economizer cycle shall be enabled either partially in conjunction with mechanical cooling or exclusively to maintain supply air temperature setpoint. Economizer shall be disabled if the OA dry bulb rises above a setpoint of 70F or the OA enthalpy rises above 26 BTU/lb. In economizer mode, the outdoor air and return air dampers shall modulate as a first stage to satisfy supply air setpoint unless unit is in 100% OA mode. The energy reclaim wheel shall run continuously during occupied periods however, if outdoor air enthalpy is below return air enthalpy and cooling is required the wheel speed shall modulate so as to allow the system to reach supply air setpoint as indicated above and herein. If the wheel is fully stopped the bypass dampers shall open to full bypass.

b. If there is a call for space dehumidification as determined by either return air dewpoint or more than 3 space zone sensors detecting a dewpoint above a setpoint of 55°F for RTU-24 or 53°F for RTU-5, 9, 15 & 19, the DX compressor stages shall stage (inverter or digital compressor shall modulate) to maintain a cooling coil temperature (as measured via refrigerant gas pressure sensor) setpoint of 45 degrees for RTU-24 and 42°F for RTU-5, 9, 15 & 19. If suction temp is not monitored than the leaving air temp. of the cooling coil shall be set to 53°F for RTU-

15 and 50°F for RTU-5,9,15 & 19. Stages shall increase as the distance and time from setpoint increase with a minimum of 5-minute delay between compressor stages (not inverter modulation). Coordinate with delays built into condenser controller. Hot gas reheat shall be modulated as required to maintain supply air setpoint.

c. Hot Gas Reheat Valve (HGRV) Purge Cycle: When the hot gas reheat valve has not been open for at least 2 consecutive minutes within the last hour and a compressor is running in the reheat circuit, the hot gas reheat purge cycle shall be enabled and the HGRV shall be forced 100% open for an adjustable purge duration of 2 minutes. The purge cycle may occur once every 60 minutes (adj.).

d. Supply air discharge setpoint shall be reset between 55°F and 70°F based on an average of the cooling demand from spaces. If more than 3 zones on the system are above cooling setpoint by greater than a setpoint of 3°F, the supply air reset schedule shall reset down towards the minimum overriding the average demand.

e. Morning Cool-Down: If the average space temperature is above cooling setpoint and it is within 2-hours (adj.) of a scheduled occupied period the EMS shall calculate an optimized start-time to achieve space setpoint and enable the unit into morning cool-down mode. The supply air temperature shall be reset down to 55°F until the average space temperature reaches cooling setpoint or the return air temperature reaches 75°F whichever comes first at which time the unit shall drop out of morning cool-down mode and enter normal occupied operation at the schedule time. Unit shall also operate to ensure the space dewpoint drops below 54F before allowing associated chilled beam and sensible only chilled water coil valves from opening.

f. If airflow is not proven via a pressure sensor an adjustable differential pressure sensor across the DX coil, the compressors circuits shall be deactivated without regard for minimum compressor run times (coordinate with compressor controller).

6. Heating Control

a. The hot water heat valve shall modulate if required to maintain the supply air reset schedule as identified in the cooling sequence initially 55°F to 70°F. Hot water valve shall be closed if DX cooling or dehumidification mode is operational.

b. During morning warm-up or cool down the supply air reset schedule shall be overriden and the coil valve shall modulate to satisfy the reset schedule indicated herein.

c. Morning Warm-up: If the average space temperature is below heating setpoint and it is within 2-hours (adj.) of a scheduled occupied period the units the EMS shall calculate an optimized start-time to achieve space setpoint and enable the unit into morning warm-up mode. The supply air temperature shall be reset up 90°F until the average space temperature reaches heating setpoint or the return air temperature reaches 70°F whichever comes first at which time the unit shall drop out of morning warm-up mode and enter normal occupied operation at the schedule time

d. During morning warm-up or during any unoccupied period when outdoor air temperatures are above a setpoint of 15°F, the RTU heat pump cycle shall be the

first stage of heat followed by the hot water coils and space radiation. The intent is to minimize reliance on the fossil fuel hot water boiler plant during these conditions.

e. During unoccupied periods when outdoor air temperatures are below a setpoint of 38ºF and the unit is off, the hot water coil valves shall modulate to maintain a hot water leaving coil air temperature of 70°F to ensure minimum flow through the heating coils and to prevent nuisance trips of the freeze stats.

7. Post Fire Smoke Evacuation Mode:

a. Upon command from the fire alarm system the unit shall be enabled to operate regardless of smoke or freeze protection safety shutdown in 100% OA and EA heating only mode. The DX and the ERV wheel shall be disabled. If the system discharge air temperature drops below 40°F for longer than 30 seconds, the ATC shall report a freeze alarm but shall not shutdown.

8. System Safeties & Misc.:

a. The units have glycol in the hot water coils for freeze protection. If the hot water coil freeze stat detects a leaving air temperature below 38°F for longer than 60 seconds, the unit shall report a low temperature alarm but shall not shutdown. If the system discharge air temperature drops below 40°F for longer than 30 seconds, the ATC shall report a freeze condition to the EMS and the following shall occur:
Disable supply air and exhaust air fans.
Close the outdoor and exhaust air dampers and open the return air damper.
Open hot water coil valve 100%
Annunciate a local alarm

b. Normal damper positions are as follows:
O.A. damper – normally closed
R.A. damper – normally open
E.A. damper – normally closed

c. Smoke Alarm – Upon a smoke detector activation or if any smoke damper in the system is in a position other than fully open, the unit and fans shall shutdown and the dampers shall go to their normal position (i.e. O.A.-Closed). An alarm shall be reported to the EMS system and the building fire alarm system.

d. The factory condensing unit controller shall perform hot gas reheat coil flush cycles as needed to insure no refrigerant oil is tied up in the coils.

e. Coordinate with factory for minimum on & off times, time delays and such for compressors.

8. DDC Point List – RTU-5, 9, 15, 19, 24

a. Refer to the plans and these sequences of operation and provide all points required and inferred to make for a fully functional and operation system. Being that the units condensing section shall be BacNet compatible several points may be extracted from the interface however this contractor must provide any points and all points needed to achieve the operation and monitoring level specified. The EMS contractor shall provide all points are units are customized in this regard with the exception of

those points integral to the RTU condenser section as furnished by the manufacturer. Points in **Bold** are point supplied and/or controlled by the unit manufacturer. Unitary dampers are supplied by the unit manufacturer however, the damper motors and operators are provided by the EMS vendor. As a minimum the following points being monitored and controlled for each unit:

Inputs	Outputs
Filter Diff. Pressure AI (3)	Supply fan S/S DO
Return air volume AI	Exhaust fan S/S DO
Freezestat AI	Supply fan VFD AO
Mixed air temp. AI	O.A. damper AO
Supply duct static AI	Return Air damper AO
Supply fan status	Hot Water Coil Valve AO
amp. AI	Exhaust Fan VFD AO
Exhaust fan status/	Wheel Bypass Dampers DO (2)
amp. AI	DX Cooling Stages (multiple) DO & AO
Duct Smoke Det. DI (mult)	DX Heat Stages (mult) DO&AO
Discharge air temperature AI	**Hot Gas Reheat Valves AO (multiple)**
R.A. temperature AI	Wheel Enable and Speed DO & AO
DX Coil Press./Temp AI (mult)	Duct Smoke Damper DO (mult) coord. with EC
R.A. humidity AI	**Condenser section Bacnet Interface**
R.A. CO2 AI	Ionizer enable/disable DO
Space CO2 AI (multiple)	
Wheel discharge air temp AI	
Wheel rotation DI	
Wheel Pressure Drop AI	
Supply Duct Static Pressure AI	
Return/Exhaust Duct Static Pressure AI	
Low Limit Duct Static Pressure AI	
High Limit Duct Static DI	
Wheel Supply Leaving Temp AI	
DX Coil Air DP AI	
Duct Smoke Damper DI (mult)	
Post Fire Smoke Evac. Command DI	
Ionizer status DI	
Outdoor air volume (monitoring)	
Supply Air Volume AI	
Exhaust Air Volume AI	
Factory Discharge Air sensor	
Factory OA Temp sensor AI	
O.A. temperature AI (global) also integral to unit	
O.A. humidity AI (global) also integral to unit	
Condenser section Bacnet Interface	

Note: OA, RA and Bypass damper actuators as well as wheel rotation sensor are furnished with units but must be wired and controlled by EMS. Freezestat is furnished and installed by unit manufacturer but must be wired from terminal strip to EMS.

Z. SEQUENCE OF OPERATION – RTU-12, 13, 21 & 22 (Single Zone VAV Systems)

1. General

a. RTU- 12, 13, 21 & 22 are packaged rooftop units with energy recovery wheels units that are single zone style variable air volume (VAV) units which provide year round dehumidification, cooling, heating and ventilation to various areas of the building. The units support the following areas:
   - RTU-12 & 13: Auditorium
   - RTU-21: Gymnasium A
   - RTU-22: Gymnasium B

b. Some limited control sequences and points related to the DX condenser sections shall be accomplished via the units factory condensing unit controls which must be programmed and interfaced to the EMS. The points required to come with the unit are indicated below (in bold) as well as those points the EMS contractor must provide. EMS contractor must coordinate with RTU vendor to insure all specified sequences and points are provided.

2. Supply & Exhaust Fan Control

a. The EMS system shall compare the outdoor conditions, the space conditions and the buildings historical warm-up/cool-down profile to determine the optimum start time required to achieve space setpoint conditions by the scheduled occupied start time. The fans shall run continuous during the occupied time period. During morning warm-up mode the outdoor air dampers shall remain closed and the system shall supply air reset off the return air temperature to bring the spaces up to space heating setpoint (Refer to Heating Coil Control).

b. The EMS shall index from the occupied mode to the unoccupied mode based on a time schedule furnished by the owner. This schedule may be temporary overridden for a predetermined time period by sensor mounted override switches.

c. For all units with smoke dampers the EMS shall prove that all supply air and return/exhaust air smoke dampers are fully open prior to allowing the fans and unit to operate.

d. The bipolar ionization units shall be enabled at all times the supply fan is enabled and its status shall be monitored.

e. On RTU-21 & 22 systems, whenever the RTU system is calling for heating the respective anti-stratification fans ASF-# fans shall start and run continuously until all heating demand for the space has ended. ASF fans shall be enabled as a 1st stage call for heat. If the outdoor air temperature is below a setpoint of 40°F the ASF fans shall run continuously regardless of occupancy mode. User shall be able to control the speed of these fans by adjusting at the front-end.

3. Occupied Mode

a. At the commencement of occupied mode, the outdoor air damper shall open to its respective position with the return/recirculation air dampers going to their respective positions. The supply fan and exhaust fan shall run continuously throughout the occupied time period (see exhaust fan enable herein). If the high limit discharge air duct static sensor meets or exceeds a setpoint of 3”w.c. or the low limit return air duct static sensor meets or exceeds a setpoint of -3” w.c. the unit shall be disabled, fans shall turn off and an alarm shall be reported. The high limit duct static pressure sensor shall be located upstream (unit side) of the supply smoke dampers. The low

limit duct static pressure sensor shall be located upstream (unit side) of the return smoke dampers.

b. The supply fans shall initially operate at 40% speed (40% supply airflow) and shall speed up or down as needed to support space cooling, economizer, CO2 ventilation control or heating demands. For space temperature control the supply air temperature shall reset to minimum (for cooling) or maximum (for heating) setpoint first prior to increasing fan speed to achieve space setpoint.

c. The exhaust fan variable frequency drive shall modulate the fan speed to maintain exhaust air levels equal to outdoor air levels minus a preset offset. The exhaust damper shall open (gravity style) when the fan is enabled. The exhaust fan shall not start until the outdoor airflow volume exceeds 20% (adj.) of the scheduled minimum OA CFM. If the outdoor airflow station is determined during CX testing to not be reliable, the outdoor airflow quantity shall be calculated by using the return duct airflow station and the supply airflow station with outdoor air equal to supply airflow minus return airflow. Space pressure shall be monitored and a low level alarm reported if space pressure exceeds an initial setpoint of +0.01" with respect to outdoors. When enabled, minimum exhaust fan speed shall not be allowed to fall below a setpoint of 10Hz or as otherwise directed by the unit manufacturer.

d. Outdoor air flow dampers shall maintain outdoor air quantity constant within 10% of the specified outdoor air quantity reset as specified herein.

e. The outdoor air, return air and exhaust dampers shall modulate to maintain the minimum specified outdoor air level as determined by the flow measuring stations. Outdoor air quantity shall be varied between 25% of the specified minimum outdoor air quantity and the specified minimum outdoor air quantity in response to the space CO2 sensors, where shown on the plans, or the return air sensor, if space sensors are not identified. Dampers shall modulate to maintain a maximum CO2 level at any space sensor of no greater than 800 ppm (adj.) but in no case shall the outdoor air level exceed the scheduled minimum outdoor air value unless economizer cooling is required. Reduced outdoor air CO2 control shall be overridden in the event economizer cooling is required.

f. The energy reclaim wheel shall run continuously during occupied periods however, if outdoor air enthalpy is below return air enthalpy and cooling is required the wheel speed shall modulate to maintain supply air setpoint. Economizer shall be disabled if the OA dry bulb rises above a setpoint of 70F or the OA enthalpy rises above 26 BTU/lb. One the wheel is fully stopped, the wheel bypass dampers shall open.

g. Energy wheel speed shall modulate as frost protection for the wheel insuring that the minimum exhaust air temperature off the wheel does not fall below a setpoint as described below and reset as follows. The final accepted unit and wheel manuf. must be consulted to verify the below values are applicable for their wheel.

RA Humidity	Defrost Enable Outdoor Air Temp	Vary Wheel to Wheel Exhaust Temp
20% RH	-10 F	15 F
30% RH	0 F	20 F
40% RH	10 F	25 F

Pressure drop across wheel in excess of a predefined limit (confirm with factory) shall also indicate a potential frost condition and shall enable defrost mode.

h. If wheel run indicator detects a loss of wheel rotation either due to loss of current or reduced current indicating belt loss an alarm shall be reported by the EMS.

i. Main return air carbon dioxide levels shall be monitored and if levels exceed a maximum CO2 setpoint level of 800 ppm (adj.) or greater a low level alarm shall be reported by the EMS.

4. Unoccupied Mode

a. At the commencement of unoccupied mode the outdoor air dampers shall close and the fans shall cycle off. If required, the fans shall cycle on to maintain unoccupied space cooling and heating setpoints initially set for 88°F and 60°F respectively.

5. Cooling/Dehumidification Control

a. The total enthalpy of the return air and outdoor air streams shall be compared and, if advantageous, outdoor air economizer cycle shall be enabled either partially in conjunction with mechanical cooling or exclusively to maintain supply air temperature setpoint. Economizer shall be disabled if the OA dry bulb rises above a setpoint of 70F or the OA enthalpy rises above 26 BTU/lb. In economizer mode, the outdoor air and return air dampers shall modulate as a first stage to satisfy supply air setpoint. The energy reclaim wheel shall run continuously during occupied periods however, if outdoor air enthalpy is below return air enthalpy and cooling is required the wheel speed shall modulate so as to allow the system to reach supply air setpoint as indicated above and herein. If the wheel is fully stopped the bypass dampers shall open to full bypass.

b. If there is a call for space dehumidification as determined by return air dewpoint rising above a setpoint of 55°F the DX compressor stages shall stage (inverter compressor shall modulate) to maintain a cooling coil temperature (as measured via refrigerant gas pressure sensor) setpoint of 45 degrees. If suction temp is not monitored than the leaving air temp. of the cooling coil shall be set to 53°F. Stages shall increase as the distance and time from setpoint increase with a minimum of 5-minute delay between compressor stages (not inverter modulation). Coordinate with delays built into condenser controller. Hot gas reheat shall be modulated as required to maintain supply air setpoint.

c. Hot Gas Reheat Valve (HGRV) Purge Cycle: When the hot gas reheat valve has not been open for at least 2 consecutive minutes within the last hour and a compressor is running in the reheat circuit, the hot gas reheat purge cycle shall be enabled and the HGRV shall be forced 100% open for an adjustable purge duration of 2 minutes. The purge cycle may occur once every 60 minutes (adj.).

d. Supply air discharge setpoint shall be reset between 55°F and 90°F based on the space temperature demand.

e. Morning Cool-Down: If the space temperature is above cooling setpoint and it is within 2-hours (adj.) of a scheduled occupied period the EMS shall calculate an optimized start-time to achieve space setpoint and enable the unit into morning cool-down mode. The supply air temperature shall be reset down to 55°F until the space temperature reaches cooling setpoint or the return air temperature reaches

75°F whichever comes first at which time the unit shall drop out of morning cool-down mode and enter normal occupied operation at the schedule time.

f. If airflow is not proven via a pressure sensor an adjustable differential pressure sensor across the DX coil, the compressors circuits shall be deactivated without regard for minimum compressor run times (coordinate with compressor controller).

6. Heating Control

a. The hot water heat valve shall modulate if required to maintain the supply air reset schedule as identified in the cooling sequence initially 55°F to 90°F. Hot water valve shall be closed if DX cooling or dehumidification mode is operational.

b. During morning warm-up or cool down the supply air reset schedule shall be overriden and the coil valve shall modulate to satisfy the reset schedule indicated herein.

c. Morning Warm-up: If the space temperature is below heating setpoint and it is within 2-hours (adj.) of a scheduled occupied period the units the EMS shall calculate an optimized start-time to achieve space setpoint and enable the unit into morning warm-up mode. The supply air temperature shall be reset up 90°F until the space temperature reaches heating setpoint or the return air temperature reaches 70°F whichever comes first at which time the unit shall drop out of morning warm-up mode and enter normal occupied operation at the schedule time

d. During morning warm-up or during any unoccupied period when outdoor air temperatures are above a setpoint of 30°F, the heat pump cycle shall be the first stage of heat for the spaces served by the respective system followed by the hot water coils and baseboard radiation. The intent is to minimize reliance on the fossil fuel hot water boiler plant during these conditions.

e. During unoccupied periods when outdoor air temperatures are below a setpoint of 38ºF and the unit is off, the hot water coil valves shall modulate to maintain a hot water leaving coil air temperature of 70°F to insure minimum flow through the heating coils and to prevent nuisance trips of the freeze stats.

7. System Safeties & Misc.:

a. The units have glycol in the hot water coils for freeze protection. If the hot water coil freeze stat detects a leaving air temperature below 38°F for longer than 60 seconds, the unit shall report a low temperature alarm but shall not shutdown. If the system discharge air temperature drops below 40°F for longer than 30 seconds, the ATC shall report a freeze condition to the EMS and the following shall occur:
Disable supply air and exhaust air fans.
Close the outdoor and exhaust air dampers and open the return air damper.
Open hot water coil valve 100%
Annunciate a local alarm

b. Normal damper positions are as follows:
O.A. damper – normally closed
R.A. damper – normally open
E.A. damper – normally closed

c. Smoke Alarm – Upon a smoke detector activation or if any smoke damper in the system is in a position other than fully open, the unit and fans shall shutdown and the dampers shall go to their normal position (i.e. O.A.-Closed). An alarm shall be reported to the EMS system and the building fire alarm system.

d. The factory condensing unit controller shall perform hot gas reheat coil flush cycles as needed to insure no refrigerant oil is tied up in the coils.

e. Coordinate with factory for minimum on & off times, time delays and such for compressors.

8. DDC Point List – RTU-12, 13, 21 & 22

a. Refer to the plans and these sequences of operation and provide all points required and inferred to make for a fully functional and operation system. Being that the units condensing section shall be BacNet compatible several points may be extracted from the interface however this contractor must provide any points and all points needed to achieve the operation and monitoring level specified. The EMS contractor shall provide all points are units are customized in this regard with the exception of those points integral to the RTU condenser section as furnished by the manufacturer. Points in **Bold** are point supplied and/or controlled by the unit manufacturer. Unitary dampers are supplied by the unit manufacturer however, the damper motors and operators are provided by the EMS vendor. As a minimum the following points being monitored and controlled for each unit:

Inputs	Outputs
Filter Diff. Pressure AI (3)	Supply fan S/S DO
Return air volume AI	Exhaust fan S/S DO
Freezestat AI	Supply fan VFD AO
Mixed air temp. AI	O.A. damper AO
Supply duct static AI	Return/recirc Air damper AO
Supply fan status	Hot Water Coil Valve AO
amp. AI	Exhaust Fan VFD AO
Exhaust fan status/	Wheel Bypass Dampers DO (2)
amp. AI	DX Cooling Stages (multiple) DO & AO
Duct Smoke Det. DI (mult)	DX Heat Stages (mult) DO&AO
Discharge air temperature AI	**Hot Gas Reheat Valves AO (multiple)**
R.A. temperature AI	Wheel Enable and Speed DO & AO
DX Coil Press./Temp AI (mult)	Duct Smoke Damper DO (mult) coord. with EC
R.A. humidity AI	**Condenser section Bacnet Interface**
R.A. CO2 AI	Anti-Stratification Fans AO
Space CO2 AI (multiple)	Ionizer enable/disable DO
DX Coil Air DP AI	
Wheel discharge air temp AI	
Wheel rotation DI	
Wheel Pressure Drop AI	
Duct Static Pressure AI	
High Limit Duct Static DI	
Low Limit Duct Static DI	
Wheel Supply Leaving Temp AI	
Duct Smoke Damper DI (mult)	
Ionizer status DI	
Outdoor air volume AI (monitoring)	

Supply Air Volume AI
Exhaust Air Volume AI
Factory Discharge Air sensor
Factory OA Temp sensor AI
O.A. temperature AI (global) also integral to unit
O.A. humidity AI (global) also integral to unit
Condenser section Bacnet Interface

Note: OA, RA and Bypass damper actuators as well as wheel rotation sensor are furnished with units but must be wired and controlled by EMS. Freezestat is furnished and installed by unit manufacturer but must be wired from terminal strip to EMS.

AA. SEQUENCE OF OPERATION – VAV TERMINALS:

1. General: The VAV units provide cooling, heating (where fitted with hot water coils) and ventilation of the respective building areas.

2. If space temperature rises above an occupied cooling setpoint (initially 75 deg. F) the VAV damper shall modulate open to supply cool air to the room. Damper shall modulate open and close to its minimum position as required to maintain cooling setpoint and space CO2 setpoint (CO2 for classrooms, media and café only). Unoccupied cooling setpoint is 88°F.

3. For all VAV zones with space CO2 sensors, if space CO2 rises above a setpoint of 800 PPM a demand ventilation signal shall be sent first to the RTU to introduce more outside air. If RTU OA is at maximum OA design limit and CO2 level is still above setpoint VAV shall modulate open further to introduce more but no further than maximum supply air limit. If space overcools to below heating setpoint the CO2 VAV damper override shall be overridden and damper shall modulate to not allow space to fall below heating setpoint. If space CO2 rises above 1000 ppm a low-level alarm shall be reported.

4. Exhaust VAV boxes in locker rooms, art rooms and science rooms shall maintain space supply air offset to ensure negative space pressure relationship of -0.01 in relation to adjacent corridor. See below.

5. During morning warm-up the VAV boxes shall operate in reverse, opening to allow warm air to bring the space up to occupied heating setpoint (initially 72 deg. F.). If respective space is at heating setpoint while in morning warm-up mode the VAV box shall close.

6. <u>For units with hot water coils</u>: If space continues to cool down to the heating setpoint (initially 72 deg. F) the VAV damper shall first be at its minimum position and the hot water valve shall modulate open to maintain heating setpoint. VAV box discharge air temperature sensor shall modulate coil valve so that supply air temperature does not exceed 90°F (note: temperatures up to 100°F shall be allowed during unoccupied periods, i.e. warm-up). Upon a continued call for heat, the damper shall modulate open to allow more heated air into the space. Unoccupied heating setpoint is 60°F.

7. <u>For units with hot water and associated baseboard radiation</u>: If space continues to cool down to the heating setpoint (initially 72 deg. F) the VAV damper shall first be at its minimum position and the respective zone of baseboard radiation shall modulate open

along with the VAV heat coil to maintain space heating setpoint. During unoccupied periods when the central fan system is off, the baseboard radiation shall cycle to maintain unoccupied setpoint. Unoccupied heating setpoint is 60°F.

8. For exhaust VAV's when any science room, locker room and art room is occupied as determined by the space occupancy sensor, the exhaust VAV serving this area shall modulate as required to maintain the minimum scheduled exhaust airflow rate higher than the supply VAV box airflow rate as shown on the drawings but in no case to exceed (more negative) room negative pressure of -0.01". Space pressure shall be monitored and if space pressure during occupied period is higher (more positive) than -0.01"w.g. with respect to the main corridor for longer than 15 minutes a low level alarm shall be reported by the EMS. For exhaust VAV's serving the Janitors closet, etc… the VAV shall open to schedule maximum airflow during all occupied periods.

9. Points List

   a. As a minimum, the following points will be monitored and controlled for each VAV Unit. See also points indicated on drawings:

Inputs	Outputs
Velocity Sensor AI	Damper AO
Space temp. AI	Hot water coil valve AO
Space temp. adj AI	Baseboard Valve AO
Push button override DI	
Supply Temp AI	
Space CO2 AI	
Room Occupancy Sensor DI (via lighting control BacNet interface)	
Science, Art and Prep. Space Pressure AI	

BB. SEQUENCE OF OPERATION – DOAS VAV TERMINALS & ASSOC. CHILLED BEAMS:

1. For VAV's connected to DOAS systems (RTU-1, 2, 3, 4, 11 & 22) serving chilled beams, during scheduled occupied periods the VAV terminal shall be at no less than 50% of its scheduled airflow. The VAV damper shall modulate between 50 & 100% of tis rated airflow as required to maintain space CO2 below a setpoint of 800 PPM and space dewpoint below setpoint (initially 52°F) as well as space cooling setpoint of 75°F.

2. If the space served by a respective chilled beam has a space dewpoint above a setpoint of 53°F the chilled beam chilled water valve shall not be allowed to open until the space dewpoint drops to 52°F or below. In addition, if the pipe or pan moisture sensor detects condensation the chilled water valve shall be closed.

3. For area without CO2 sensors, during schedule occupied periods, VAV terminals shall stay at 50% minimum airflow position. Once the room occupancy sensor detects occupancy the VAV terminal shall go to its scheduled maximum airflow value and remain at this value until space goes unoccupied or the scheduled unoccupied period commences. Box shall override from unoccupied minimum position if there is a call for space cooling or space dehumidification as noted herein.

4. Upon a call for space cooling (i.e. 75°F occupied, 82° unoccupied), the VAV shall modulate from its minimum position to its maximum scheduled airflow. Once maximum position is reached the respective areas chilled beam chilled water valve shall modulate open to maintain space cooling setpoint. Unoccupied cooling setpoint only applies to

schedule unoccupied periods and does not apply to lack of occupancy as determined by the occupancy sensors during regular scheduled occupied periods.

5. Upon a call for space heating (i.e. 70°F occupied, 62° unoccupied), the hot water baseboard radiation and/or chilled beam hot water coil valve shall modulate (2-position) open. If the VAV terminal has a hot water coil, it shall modulate open after respective chilled beam or baseboard valve. Unoccupied heating setpoint only applies to schedule unoccupied periods and does not apply to lack of occupancy as determined by the occupancy sensors during regular scheduled occupied periods.

6. Refer to plans for VAV boxes which service multiple rooms and for rooms where a single thermostat may control multiple chilled beam valves.

7. Points List

   a. As a minimum, the following points will be monitored and controlled for each VAV & Chilled Beam Unit. See also points indicated on drawings:

Inputs	Outputs
Airflow CFM AI	Damper AO
Space temp. AI	Hot water coil valve DO
Space temp. adj AI	Chilled Water coil Valve AO
Push button override DI	
Supply Temp AI	
Room Occupancy Sensor DI	
Space Humidity AI (for dewpoint calc.)	
Space CO2 sensor AI	
Pan Moisture sensor DI	
Space Occupancy DI (via lighting control interface)	

CC. SEQUENCE OF OPERATION – DOAS FVAV WITH CHILLED & HOT WATER COILS

1. The DOAS FVAV units with chilled and hot water coils support the ventilation, cooling and heating needs of the respective areas served.
2. During scheduled occupied periods the FVAV supply fan shall operate at a fixed speed and the VAV terminal shall be at no less than 50% of its scheduled airflow. The VAV damper shall modulate between 50% & 100% of its rated airflow as required to maintain space CO2 below a setpoint of 800 PPM and space dewpoint below setpoint (initially 52°F) as well as space cooling setpoint of 75°F.

3. For area without CO2 sensors, during scheduled occupied periods, VAV terminals shall stay at 50% minimum airflow position unless space dewpoint rises above setpoint or space temperature rises above setpoint at which point the damper shall modulate open to hold these setpoints. Once the room occupancy sensor detects occupancy the VAV terminal shall go to its scheduled maximum airflow value and remain at this value until space goes unoccupied or the scheduled unoccupied period commences.

4. If the space served by a respective terminal has a space dewpoint above a setpoint of 53°F the chilled beam chilled water valve shall not be allowed to open until the space dewpoint drops to 52°F or below. In addition, if the pipe or pan moisture sensor detects condensation the chilled water valve shall be closed

5. Upon a call for space cooling (i.e. 75°F occupied, 82° unoccupied), the VAV shall modulate from its minimum position to its maximum scheduled airflow. Once maximum position is reached the units chilled water valve shall modulate open to maintain space cooling setpoint. Unoccupied cooling setpoint only applies to scheduled unoccupied periods and does not apply to lack of occupancy as determined by the occupancy sensors during regular scheduled occupied periods.

6. Upon a call for space heating (i.e. 70°F occupied, 62° unoccupied), the VAV damper shall go to its minimum 50% position unless space dewpoint or CO2 require more air and the hot water coil valve shall modulate open subject to a maximum discharge air temperature of 90°F (note: temperatures up to 100°F shall be allowed during unoccupied periods, i.e. warm-up). Unoccupied heating setpoint only applies to schedule unoccupied periods and does not apply to lack of occupancy as determined by the occupancy sensors during regular scheduled occupied periods

7. During unoccupied periods the unit fan shall remain off and shall cycle on and off as needed to maintain unoccupied space temperature setpoint initially set for 60F heating and 85F cooling.

8. DDC Point List:
As a minimum the following points shall be monitored and controlled for each hot water fan coil unit:

Inputs	Outputs
Space Temperature AI	Fan start/stop & Speed DO & AO
Supply Air Temp AI	Hot Water Coil valve DO
Supply Air Temp AI	Chilled Water Coil valve DO
Fan Status AI	Damper AO
Airflow CFM AI	
Space Humidity AI (for dewpoint calc.)	
Space CO2	
Pan Moisture sensor DI	
Space Occupancy DI (via lighting control interface)	

DD. SEQUENCE OF OPERATION - ELECTRIC CABINET, BASEBOARD & PANEL HEATERS

1. For Electric Cabinet Heaters: Integral adjustable thermostat shall enable and disable heaters and fan to maintain space temperature setpoint initially set for 60°F for utility and entry vestibule areas and a setpoint of 60°F during unoccupied periods and 68°F during occupied periods for no utility areas. EMS shall have full interface control via BacNet and the EMS shall be able to control unit setpoint and start/stop feature thru this interface as specified. For rooms where a wall thermostat is reflected on the drawings the unit shall be controlled by the EMS with a setpoint of 62°F. EMS shall monitor space for low or high temperature alarms.

2. For Electric Baseboard and Radiant Panel Heaters: EMS shall enable and disable power to the respective heaters to maintain space temperature setpoint initially set for 60°F during unoccupied periods and 68°F during occupied periods.

3. DDC Point List Electric Cabinet Heaters:
As a minimum the following points shall be monitored and controlled for each electric cabinet heater:

Inputs	Outputs
Space Temperature – A.I.	Heater Enable/Disable DO

EE. SEQUENCE OF OPERATION - HOT WATER UNIT & CABINET HEATER

1. Space mounted temperature sensors shall enable and disable heater fans as required to maintain space temperature setpoint initially set for 62°F during unoccupied periods and 72°F during occupied periods. On cabinet heaters, a valve shall also cycle with the fan. If system is not in heating mode the fan shall be disabled.
2. DDC Point List:
   As a minimum the following points shall be monitored and controlled for each hot water unit heater and cabinet heater:

Inputs	Outputs
Space Temperature AI	Fan start/stop DO
	Coil valve DO (only on cabinet unit heaters)

FF. SEQUENCE OF OPERATION DUCTLESS SPLIT UNITS (non VRF):

1. The building EMS shall monitor and control the ductless split units. Once enabled, the units shall stage on and off on their own factory controls.
2. The thermostat upon sensing a change in space temperature from setpoint shall stage cooling to maintain setpoint. Indoor fan shall cycle with cooling demand as required. Initially setpoints shall be 75°F for cooling. Coordinate with zones with VAV boxes to insure ductless split unit cooling setpoint is set at least one degree higher than VAV box setpoint. Building shall alarm conditions more than 4°F beyond this limit.
3. For units with condensate pumps, the pump high level condensate float shall be monitored and if a high level is recorded, an alarm shall be sent to the EMS and the cooling mode shall be disabled.

   a. DDC Point List:
      As a minimum the following points shall be monitored and controlled through the EMS

Inputs	Outputs
Space Temperature AI	Enable/Disable DO
BacNet Interface to factory space sensor and unit control	
Condensate Pump DI	

GG. SEQUENCE OF OPERATION – GENERAL & BATHROOM EXHAUST FANS

1. All general & bathroom exhaust fans shall be controlled through the DDC and shall operate continuously during the occupied periods or as otherwise indicated herein.
2. At commencement of occupied periods motorized dampers shall open and respective exhaust fans shall start and run.
3. During unoccupied periods the exhaust damper shall close and the exhaust fans shall be disabled.

4. Radon exhaust fans shall run continuously 2 hours per day 7 days per week. The EMS shall monitor these fans and report and alarm condition when the electrical current status from the fan drops below setpoint or when the DP across the fan(s) detects a failed condition.

5. Exhaust fans shown or scheduled as serving heat producing non occupied rooms shall cycle and open respective exhaust dampers as required to maintain a cooling setpoint, initially 85°F. Coordinate with E.C. for fans controlled by line voltage thermostats.

6. For fans scheduled with ECM motors or variable speed drives reflected on the control drawings with a VFD, the EMS shall send a 0 to 10 VDC signal to start and stop the fan and modulate its speed. For fans scheduled with ECM motors reflected on the control drawings with a HS or HOA, the EMS shall send a 0 to 10 VDC signal to start and stop the fan and the final running control voltage signal shall be coordinated with the balancer. For fans scheduled with ECM motors reflected on the control drawings with a HS or HOA and also scheduled to have a potentiometer dial, the EMS shall send a start and stop signal to the fan.

7. DDC Point List – Bathroom & General Exhaust Fans

   As a minimum the following points shall be monitored and controlled for each fan:

Inputs	Outputs
Space Temperature – AI	Start/Stop - DO
Run Indicator AI	Damper – DO
Fan DP – DI (adj.)	
Occupancy Sensor – DI (from lighting control system)	
VFD Start/Stop DO	
Space Pressure AI	VFD Speed AO
	ECM VFD Fan Start/Stop & Speed AO
	ECM HS/HOA (no potentiometer) Start/Stop AO
	ECM HS/HOA (with potentiometer) Start/Stop DO

HH. SEQUENCE OF OPERATION – Heat Pumps (ACHP & associated FC's):

1. Based on an occupancy schedule, the fan coil zones shall cycle their fans, branch selector valve and respective heat pump unit for cooling or heating as required to maintain scheduled space temperature setpoint initially set for 72°F occupied & 62°F unoccupied for heating and 75°F occupied and 88°F unoccupied for cooling. On FC-# & FC-# if a room occupancy sensor detects space occupancy (via occupancy sensor or information from lighting control system), the respective units fan coil fan shall operate continuously and is outdoor air damper shall open. For FC-1 the ILF-3 fan shall be enabled to provide minimum fresh air to the system.

2. During occupied periods, the fan coil fan shall operate on low speed when room conditions have met setpoint and shall speed up as needed when space demand requires either cooling or heating. In unoccupied rooms or rooms where ventilation is provide external to the FC system the fan shall be allowed to cycle on & off as needed to support space cooling or heating.

3. If a fan coil unit with integral condensate drain pump detects an overflow condition in the condensate pump well, the fan coil cooling cycle shall be disabled and an alarm shall be reported to the front-end.

4. BMS shall communicate with VRF system to prevent simultaneous cooling and heating in the space as well as to acquire all space temperature conditions, setpoints and system status.

5. Points List: Refer to the plans and these sequences of operation and provide all points required and inferred to make for a fully functional and operation system. Being that the unit shall be BacNet compatible many points may be extracted from the interface however this contractor must provide any and all points needed to achieve the operation and monitoring level specified. Refer to VAV and ERU sequence for additional interface points and logic. Points in **Bold** are VRF manuf. devices. As a minimum, the following points will be monitored and controlled for each fan coil unit.

Inputs	Outputs
Space temp. AI	**Fan Coil Fan S/S DO/AO (mult. speed)**
Space temp. adj AI	**Fan Coil Cooling S/S DO**
Push button override DI	**Fan Coil Heating S/S DO**
Unit Alarm DI	Occ. command DO
Space temp AI (EMS)	Enable/Disable DO
Space Occupancy DI (for FC-# & FC-#)	
Condensate Pump Alarm DI	Outdoor air Damper DO
ILF-# Status DI	ILF-# Start/Stop DO

Note: Most points above are part of the VRF package. EMS must install and wire all VRF control devices and acquire data from the VRF system via BacNet for control reset and scheduling.

II. SEQUENCE OF OPERATION – Ductless Split Variable Refrigerant Flow System Non Heat Recovery - VRF (VRF ACCU-# & associated FC's):

1. Most non heat recovery VRF units support unoccupied spaces or occupied spaces supported with outside air ventilation provided directly to the rooms from other systems. In addition, these systems are primarily intended to operate in a cooling only mode although changeover to heating mode shall occur if more than 75% of the FC zones are calling for heating, which once addressed, the unit shall switch back to cooling mode.

2. The FC units shall generally operate in a fan cycle mode. For occupied areas, based on an occupancy schedule, the fan coil zones shall cycle their fans and respective heat pump unit for cooling or heating as required to maintain scheduled space temperature setpoint initially set for 72°F occupied & 62°F unoccupied for heating and 75°F occupied and 88°F unoccupied for cooling.

3. For units serving, electric rooms, tel/data closets and other similar spaces, the unit fan coil zones shall cycle their fans and respective heat pump unit for cooling or heating as required to maintain a fixed space temperature setpoint initially set for 72°F for tel/data rooms and 80°F for electrical rooms.

2. The fan coil fans shall vary fan speed as required to support space conditions. The fan shall be allowed to cycle off until such time as occupancy is realized or if space cooling or heating is required.

3. If a fan coil unit with an integral or external condensate drain pump detects an overflow condition in the condensate pump well, the fan coil cooling cycle shall be disabled and an alarm shall be reported to the front-end.

4. BMS shall communicate with VRF system to prevent simultaneous cooling and heating in the space as well as to acquire all space temperature conditions, setpoints and system status.

5. Points List: Refer to the plans and these sequences of operation and provide all points required and inferred to make for a fully functional and operation system. Being that the unit shall be BacNet compatible many points may be extracted from the interface however this contractor must provide any and all points needed to achieve the operation and monitoring level specified. Refer to VAV and ERU sequence for additional interface points and logic. Points in **Bold** are VRF manuf. devices. As a minimum, the following points will be monitored and controlled for each fan coil unit.

Inputs	Outputs
Space temp. AI	**Fan Coil Fan S/S DO/AO (mult. speed)**
Space temp. adj AI	**Fan Coil Cooling S/S DO**
Push button override DI	**Fan Coil Heating S/S DO**
Unit Alarm DI	Occ. command DO
Space Occupancy DI (in normally occupied rooms)	
Condensate Pump Alarm DI	

Note: Most points above are part of the VRF package. EMS must install and wire all VRF control devices and acquire data from the VRF system via BacNet for control reset and scheduling.

JJ. SEQUENCE OF OPERATION – FUME HOOD EXHAUST FANS

1. Upon activation of any of the fume hood switches mounted on face of hood or upon opening of a fume hood sash, the EMS shall open the main exhaust damper and enable the respective fume hood fan and the fume hood airflow monitoring system shall be activated. Activation can also be programmed via schedule depending on Owner preference. Respective RTU serving this space shall be placed in an occupied mode to support the make-up air demand (see respective RTU control).

2. The VFD shall modulate fan speed as required to maintain an exhaust duct negative static pressure initially set for -0.75” and shall be field adjusted during balancing.

3. The respective fume hood exhaust damper shall modulate so as to maintain an open sash velocity of no less than 100 FPM or as otherwise specified by hood manufacturer. Low airflow alarms lasting longer than 30 seconds shall be reported by the EMS.

4. EMS shall command all hoods to “Hibernate Mode” at the end of occupied periods unless otherwise scheduled.

5. DDC Point List – EF-1 System:
As a minimum the following points shall be monitored and controlled for this system. Refer to control drawings for additional information:

Inputs	Outputs
Run Indicator – AI	EF-# Fan Start/Stop - DO
Duct Static – AI	EF-# Damper – DO (multi)
Hood Enable/Disable – DI (multi)	EF-# VFD Fan Speed - AO

Hood Velocity Sensor – AI (multi)
Hood Velocity Alarm – DI (multi)
Hibernate Enable – DI (multi)
Hood Exhaust Damper – AO (multi)
Hibernate Command – DO (multi)

KK. SEQUENCE OF OPERATION – KILN AND KILN ROOM EXHAUST FAN

1. The Kiln exhaust fan shall be controlled through the kiln's factory controller. The kiln room exhaust fan shall be controlled through the DDC and shall operate continuously when either of the room occupancy sensors detect room occupancy or if the room temperature exceeds a setpoint of 78°F. When enabled the kiln room fan damper shall open. The EMS shall monitor both the room exhaust fan and the kiln exhaust fan status.
2. During unoccupied periods and if the Kiln exhaust fan is off the exhaust dampers shall close and the exhaust fans shall be disabled.
4. DDC Point List – Kiln Room Exhaust Fan EF-#

   As a minimum the following points shall be monitored and controlled for each fan:

Inputs	Outputs
EF Fan Run Indicator AI	Start/Stop & Fan Speed – DO & AO
Kiln Exhaust Fan status DI	Damper – DO
Kiln Exhaust Fan Proof DP DI	
Occupancy Sensor (#)	

LL. SEQUENCE OF OPERATION - HOT WATER FAN COIL UNITS

1. The hot water fan coil units primarily support unoccupied areas. Space mounted temperature sensors shall cycle the unit valve open and enable and disable the fan as required to maintain space temperature setpoint initially set for 60°F.
2. DDC Point List:
   As a minimum the following points shall be monitored and controlled for each hot water fan coil unit:

Inputs	Outputs
Space Temperature AI	Fan start/stop DO
Supply Air Temp AI	Coil valve DO

MM. SEQUENCE OF OPERATION – CHILLED WATER FAN COIL UNITS – ELECTRICAL ROOMS

1. The chilled water fan coil units primarily support unoccupied areas. Space mounted temperature sensors shall cycle the unit valve open and enable and disable the fan as required to maintain space cooling temperature setpoint initially set for 80°F.
2. DDC Point List:
   As a minimum the following points shall be monitored and controlled for each hot water fan coil unit:

Inputs	Outputs
Space Temperature AI	Fan start/stop DO
Supply Air Temp AI	Coil valve DO

NN. VEHICLE GARAGE VENTILATION

1. The Vehicle Storage Garage is ventilated by multiple exhaust fans and associated intake louvers.

2. If any of the carbon monoxide (CO) and nitrous dioxide (NO2) control sensors in the respective zone segment of the garage go into low level or high level alarm, the associated EF fan shall operate and the associated exhaust damper and intake louver damper shall open. Fans shall run until alarm condition has subsided for at least 5 minutes. ILF-1 and 2 and associated intake dampers shall operate as one zone and ILF-3 and ILF-4 and associated intake dampers shall operate as another zone.

3. Warning and fan activation levels shall be initially set for 25ppm for CO and 3 ppm for NO2. High level audible and visual alarm conditions shall be at setpoints of initially CO=50ppm and NO2=5ppm. All setpoints are adjustable. Horns shall sound and beacons flash in the respective zone until the alarm levels subside or until manually silenced at the control panel.

4. If CO and NO2 levels are below low-level alarm conditions, ILF-2 exhaust damper shall open and fan shall operate at 15% speed and ILF-3 damper shall open and fan shall operate at 10% speed to maintain minimal space ventilation. The minimum ventilation fans shall rotate between ILF-2 & 3 pair to ILF-1 & 4 pair every 72 hours for even run time. In this mode, all the OA intake louvers shall remain closed as infiltration shall provide the required make-up air while keeping the garage under negative pressure with respect to the rest of the adjoining structure. If the garage is completely empty with no vehicles parked within, the system shall be allowed to shut-down completely.

5. Post Fire Smoke Evacuation Mode:

   a. Upon command from the fire alarm system the garage ventilation system shall be enabled regardless of smoke or freeze protection safety shutdown into 100% OA and EA mode with fans at maximum programmed and balanced airflow.

6. DDC Point List – Garage Ventilation

   As a minimum the following points shall be monitored and controlled for each fan:

Inputs	Outputs
Space Temperature – AI (mult.)	Fan Start/Stop – DO (mult.)
Run Indicator AI (mult)	Intake Damper – DO (mult.)
CO/NO Sensors (mult)	Exhaust Damper – DO (mult.)
CO/NO Low Alarm (mult)	
CO/NO High Alarm (mult)	
Occupancy Sensor (mult)	
Manual Switch (DI)	
Post Fire Smoke Evac - DI	

OO. SEQUENCE OF OPERATION - STAIR TOWER PRESSURIZATION

1. The stair tower pressurization systems shall be enabled and disabled by the interface to the fire alarm system (FACP). The FACP shall be directly wired to enable/disable and monitor the system. The EMS contractor shall program the VFD and furnish and wire the respective intake and relief dampers to the VFD controller. Once enabled, the EMS system shall control the fan speed as specified herein.

2. Upon building fire alarm activation of the system, the FACP shall send an enable command to the SPF fan VFD. The VFD shall programmed and wired to command the intake and relief dampers open and prove the intake dampers is open prior to allowing the VFD to start the fan. Fans shall vary speed to maintain stair tower pressure with respect to outdoors to no less than 0.1"w.c and no more than 0.35" w.c. with a current control setpoint of 0.15" w.c. System shall continue to run until disabled and reset at the fire fighters control panel. A run report shall be saved and logged by the FACP. Note: This pressure setpoint shall be adjusted during balancing to ensure proper operation of door operators is maintained with the lowest allowable being 0.1" w.c..

3. The pressure relief damper shall open fully when the system is enabled. The EMS shall monitor the damper open and closed position and report an alarm if the damper is not in the proper position (i.e. not open when system is enabled and not closed if system is disabled). A counterweighted backdraft damper in line with relief damper shall be adjusted to maintain a static pressure in the stair tower of no greater than 0.25" w.c.. Note: This relief damper pressure shall be adjusted during balancing to ensure proper operation of door operators is maintained.

4. To enable the Manual Override feature for the stair tower fans a key operated switch must be toggled from Auto Mode to Manual Override mode.

5. If the duct smoke detectors located in the main supply duct near the top floor of each stair tower detect smoke and go into alarm the respective stair tower pressurization fan shall be disabled however the intake damper shall remain open to allow the shaft to vent smoke. A blue indicator light shall turn on at the graphic panel indicating which fan is disabled due to this condition.

6. Every week at a preset time the system shall activate and run for 60 seconds or as long as required to establish normal operation. Upon completion of weekly test and proof of normal operation, the printer shall print out the weekly test report. If normal operation is not established within 120 seconds during the weekly test the fans shall be disabled, dampers shall close and the FACP shall report a trouble alarm and the printer shall print out the weekly test report identifying the fault items.

7. A lamp test switch shall be programmed to light all LED indicator lights on the panel when pushed.

8. Points List – Stair Tower Pressurization System:
As a minimum the following points shall be monitored and controlled for each stair tower pressurization fan system. **All items in Bold shall be wired to the FACP panel and directly controlled by such**. Non bolded items shall be controlled by the EMS. Refer to control drawings for additional information:

Inputs	Outputs
SPF-# Flow Proof DP – DI	**SPF-# Fan Start/Stop - DO**
SPF-# Isolation Damper Open Ind.- DI	SPF-# Isolation Damper – DO
SPF-# Isolation Damper Closed Ind.-DI	SPF-# VFD Fan Speed - AO
FACP Alarm Command – DI	SPF-# Pressure Relief Damper – DO
Duct Smoke Detector – DI	
FACP Manual Override – DI	
Power Disconnect Position – DI	
Space Static Pressure – AI (for VFD)	
EMS VFD Interface via BacNet	

Note: As noted previously all dampers shall be furnished and wired by the EMS as indicated even if FACP is inevitably controlling.

PP. SEQUENCE OF OPERATION – COMPUTER ROOM AC UNITS (CRAC-1 & 2):

1. The building EMS shall monitor and control via enabling and disabling the computer room AC units. Once enabled, the units shall stage and control on and off on their own factory controls.

2. The CRAC unit thermostat upon sensing a change in space temperature from setpoint shall stage cooling to maintain setpoint. Indoor fan shall remain on 24 hours per days, 76 days per week. Initially cooling setpoint shall be 75°F and a heating setpoint shall be 5F lower than the cooling setpoint. The unit shall enable a dehumidification cycle to maintain a maximum humidity setpoint of 55% RH. The units electric reheat shall operate as needed to prevent space overcooling and maintain space setpoint. The unit humidifier shall stage as required to support the space humidification setpoint of 35%RH. Building EMS shall alarm conditions more than 4°F beyond this limit or if an alarm is reported by either of the CRAC units.

3. If the chilled water supply system is active (which should be 24 hours per day) as a first stage of cooling the unit controls shall enable the chilled water precooling coils first ahead of DX cooling with DX cooling operating in conjunction with or alone to maintain setpoint.

4. The condensate and humidifier waste pump high level float shall be monitored and if a high level is recorded, an alarm shall be sent to the EMS and the humidifier shall be disabled. In addition, cooling mode also be disabled but ini no event so both CRAC units have their cooling disabled.

5. If the chemical suppression system activates in the space, the fresh air VAV terminal serving the space as well as its duct smoke damper and the purge exhaust smoke damper shall close.

6. After the gas evacuation system has activated and the fire department wishes to purge the room of extinguishing agent, the FD may enable a manual key operated switch with pilot light located outside the room which shall enable the emergency evac fan. When the switch is place in evac position, the evacuation fan damper and smoke damper shall open and the fan shall be enabled. In addition the fresh air VAV damper and intake smoke damper shall also open.

7. Upon activation

   a. DDC Point List:
   As a minimum the following points shall be monitored and controlled through the EMS for each CRAC system.

Inputs	Outputs
Space Temperature AI	Enable/Disable DO CRAC-1
Space Humidity AI	Enable/Disable DO CRAC-2
Fire Suppression System Activation DI	Fresh Air VAV AO
VAV airflow AI	Smoke Damper DO (2)
Manual Evac Switch DI	Evacuation Fan start/stop DO
BacNet Interface to factory controls	Pilot Light DO
Condensate Pump DI	

QQ. SEQUENCE OF OPERATION: MISCELLANEOUS MONITORING & ALARMS

1. Kitchen Cooler & Freezer Alarm – If the cooler temperature drops below 32°F degrees or rises above a setpoint of 42°F for longer than 30 minutes an alarm shall be reported by the EMS. If the freezer temperature rises above a setpoint of 15°F for longer than 30 minutes an alarm shall be reported by the EMS.

2. The EMS shall monitor the main water meter serving the building as well as the main domestic hot water meter and the boiler water meter and report flow and totalize daily and monthly.

3. The EMS shall monitor the domestic hot water boilers and monitor and control the domestic water recirculation pump. The EMS shall monitor the domestic hot water tank temperatures and recirculation temperatures. If the tank temperatures should fall below a setpoint of 110°F for longer than 60 minutes, an alarm shall be reported by the EMS. The domestic hot water recirculation pumps shall operate during all occupied periods. During unoccupied periods the recirculation pumps shall be disabled. If pumps are placed in extended unoccupied mode (i.e. weekends, school vacations, etc…), they shall be programmed to operate a minimum of 30 minutes for every 24 hours of off time to mitigate potential stagnant water issues.

4. The EMS shall provide two (2) potable water flow switch (one in each of the emergency shower loops) set to alarm should flow rate exceed 10 GPM. If in alarm it shall report to the EMS as a high level alarm and shall be indicate as “Emergency Shower Flow – Science Rooms” or other area served at the front end.

5. The EMS shall monitor hourly and total gas usage from the main building, heating boilers and the domestic hot water heaters.

DDC Point List

a. Refer to the plans and these sequences of operation and provide all points required and inferred to make for a fully functional and operation system. As a minimum the following points being monitored and controlled:

Inputs	Outputs
	Recirc Pumps Start/Stop DO (4)
	Horn & Strobe DO (2)
Freezer Temperature AI	
Cooler Temperature AI	
Domestic Boiler BLR-1 Status DI	
Domestic Boiler BLR-1 Alarm DI	
Recirc Pump Status AI (4)	
Domestic WH Storage Temp #HWS-1 AI	
Domestic WH Storage Temp #HWS-2 AI	
Building Water Meter AI	
Dom. Water Heating Water Meter AI	
Heating Boiler Water Meter AI	
Main Domestic HW Temp AI	
Main Gas Meter AI	
Boiler Gas Meter AI	
Dom Water Heater Gas Meter AI	
CO Sensor AI	

Emergency Shower Flow DI (2)

PART 3 - EXECUTION

3.01 SURFACE CONDITIONS

A. Examine the areas and conditions under which work of heating, ventilating and air conditioning system will be performed. Correct conditions detrimental to timely and proper completion of the Work. Do not proceed until unsatisfactory conditions are corrected.

3.02 INSTALLATION

A. Install equipment ductwork, piping and controls where shown with recognized industry standards and practices, to ensure that installation complies with requirements and serves intended purposes.

B. Coordinate with other work as necessary to interface installation of ductwork, piping and equipment with other components of systems.

C. Installation of Ductwork

1. Installation of ductwork shall be coordinated with other work as necessary to interface installation or ductwork with other components of systems. Duct sizes shown on the drawings at connection to fans or other equipment may vary in actual installation. Contractor shall provide transition pieces as required. Ducts, casings and hangers shall be installed straight and level and shall be free of vibration and noise when fans are operating. All ducts shall be protected and sealed during construction to prevent moisture and dust entry. After installation duct segments and systems shall be pressure tested per SMACNA standards.

2. Provide fire safing to close all floor and wall (where fire rated) openings around ductwork - pack annular space with rockwool and 18 gauge sheet metal safing.

3. Seal the ductwork at joists and seams with LEED EQ. Credit compliant water based duct sealer DuctMate® EZ-Seal or approved equal.

4. When ductwork penetrates an insulated joist bay in the attic area, maintain insulation integrity. Support ductwork to prevent movement and secure insulation and fill all gaps.

5. 1/8” thick galvanized steel angle irons shall be used to support ductwork mounted on the roof. Angles shall be securely fastened to the ductwork and the roof before installation of the roofing membrane. Roofer shall flash in angle supports.

6. This contractor is responsible for sleeving all duct penetrations before pouring of slab. If additional holes are required this contractor shall have pay for the coring of such holes in coordination with the general contractor and with prior consent of the Architect.

7. Fabrication, installation, sealing, protecting and testing of all ductwork and duct liner shall comply with the most recent publications from the Sheet Metal and Air Conditioning Contractors' National Association (SMACNA) including but not limited to the following. All smoke control ductwork must be pressure tested as well as all other ductwork required by code and/or otherwise required by SMACNA standards described herein:

- SMACNA IAQ Guidelines for Occupied Buildings under Construction with special emphasis placed on the section regarding Duct Cleanliness and Protection for New Construction.
- SMACNA Duct Cleanliness for New Construction Guideline.
- This project must comply with SMACNA Duct Cleanliness Guidelines Advanced Level.
- SMACNA HVAC Duct Construction Standards – Metal and Flexible
- SMACNA Air Duct Leakage Test Manual

8. Duct pressure tests shall take place after all takeoffs and wall penetrations are in place and before applying exterior insulation. Correct any leaks found. Pressure test all high-pressure ductwork (duct rated for over 3"w.g.) as well as all kitchen hood exhaust ductwork, all dust collector ductwork, all smoke control ductwork (i.e. stair pressurization) and 25% of all medium and low pressure ductwork (ductwork rated for under 3" w.g.) on the project at 150% of its duct construction class pressure in accordance with SMACNA standards.

9. Duct leakage testing shall be per SMACNA HVAC Air Duct Leakage Test Manual. Provide orifice assembly including straightening vanes, orifice plate mounted in straight tube with properly located pressure taps, and U-tube manometer or other device as specified by SMACNA. Submit leak test report in SMACNA format along with ductwork drawings for designer review.

10. All ductwork shall be shipped to the site with protective film on all open connections to prevent dust from entering. Film shall be reapplied to all open ends as the duct is installed until such time as building is clean and system is ready for start-up

D. Installation of Piping

1. Contractor shall examine location where the piping is to be installed and determine space conditions. Provide and erect in a workmanlike manner, according to the best practices of the trade, all piping shown on the Drawings or required to complete the installation intended by these Specifications.

2. All drain piping from condensate drain pans shall be properly trapped in accordance with the static pressures involved. Condensate drain piping sizes shall be not less than 3/4 inch.

3. This contractor is responsible for coring of all holes related to his/her work in coordination with the general contractor and with prior consent of the Architect.

4. Provide fire safing to seal all floor and wall (where fire rated) openings around piping.

5. Provide 24 hour duration pressure test for all piping systems. Test pipes with clear water (propylene glycol mix if freezing could occur) at 1.5 times the system design pressure unless a more stringent or lengthy test is required by the local AHJ or under other Divisions. Any products or materials not rated for this pressure or the relief pressure must be isolated from the test. Provide a temporary 100 psi relief device on the tested system(s) to avoid damage due to thermal expansion during the test. Record ambient and system water pressure and temperature at start and end of test and report to Engineer. Inspect piping for leaks and if any are found repair and repeat test.

6. All systems shall be thoroughly flush with clear water and then filled with clear water and circulated for a period no less than 8 hours. Drain water, clean all strainers and then refill the hot water system with clean water and chemically treat.

7. For glycol systems, once the piping is tested and flushed, fill the system with a pre-mixed concentration of 30% corrosion inhibited propylene glycol.

E. Installation of Equipment

1. Contractor shall examine location where equipment is to be installed and determine space conditions and notify Architect, in writing, of conditions detrimental to proper and timely completion of work.

2. Install equipment where shown in accordance with manufacturer's written instructions.

3.03 FIELD QUALITY CONTROL

A. Upon completion of installation of the automatic temperature control system and after motors have been energized with normal power source, test system to demonstrate compliance with requirements. When possible, field correct malfunctioning controls then retest to demonstrate compliance. Replace controls, which cannot be satisfactorily corrected. Refer to Section - Test and Balancing. Fully coordinate all testing with the commissioning agent. In addition, to the commissioning agents reports, the balancing contractor (TAB) and the controls contractor shall submit written reports of testing procedures and findings.

3.04 SERVICE

1. After completion of the control system installation, the controls contractor shall regulate and adjust all thermostats, control valves, damper motors, etc., and place in complete operating condition, subject to the approval of the Owner. Complete instructions shall be given to the operating personnel. There shall be 40 hours of instruction given on the operation of the entire system at a training schedule determined by the Owner.

2. Start-Up and Commissioning

For all boilers, air handlers, rooftop units, etc… provide factory service/start-up technician to check, test and start equipment. Technician shall coordinate mapping of all control points with EMS contractor and commissioning of unit. Technician shall work with project commissioning agent to verify proper operation of unit. In coordination with the mechanical contractor and control contractor the factory technician shall provide Owner training of unit controls, maintenance, etc…

3.05 TESTING, ADJUSTING AND BALANCING (TAB)

A. General

1. Section Includes
   a. Testing, adjusting, and balancing of Air Systems.
   b. Testing, adjusting, and balancing of Hydronic Systems.
   c. Measurement of final operating conditions of HVAC Systems.
2. Related Documents
   a. Drawings and General Provisions of Contract, including General and Supplementary Conditions, apply to work of this section.

b. Reference 220000 Plumbing for related flow meters, switches, etc… the HVAC monitors.

3. References
   a. ASHRAE - Standard 111 - 1988 Practices for Measurement, Testing, Adjusting, and Balancing of Building Heating, Ventilation, Air Conditioning, and Refrigeration Systems.
   b. ASHRAE - 2007 HVAC Applications Handbook: Chapter 37, Testing, Adjusting and Balancing.
   c. AABC- National Standards for Total System Balance.
   d. NEBB - Procedural Standards for Testing, Balancing and Adjusting of Environmental System.
   e. SMACNA - HVAC System Testing, Adjusting and Balancing.
   f. Sheet Metal Industry - Certification of Testing, Adjusting and Balancing Technicians.
   g. ASHRAE 110 Methods of Testing and Performance of Laboratory Fume Hoods.
4. Quality Assurance
   a. Agency shall be a firm specializing in the adjusting and balancing of systems
      specified in this Section with minimum three years documented experience, acceptable to the Designer.
   b. Perform the work under the supervision of one of the following:
      1) AABC Certified Test and Balancing Engineer.
      2) NEBB Certified Testing, Balancing, and Adjusting Supervisor.
      3) TABB Certified Contractor.
   c. Work shall be performed only by a Balancing Sub-Sub Contractor which employs
      Certified Testing, Adjusting and balancing Technicians as listed by the Sheet Metal Industry National Certification Board for TAB Technicians.
   d. The work must be performed by a Certified Testing, Adjusting and Balancing Technician who may be assisted by other TAB Technicians. The Certified Testing, Adjusting and Balancing Technician is responsible for:
      1) Procedures to follow.
      2) Accuracy of all testing.
      3) Integrity of recorded data
      4) Entering all data and any abnormal or notable conditions in report forms.
      5) Initialing and dating each sheet.
   e. The General Section of the Balance Report shall include the names, signatures, and registration numbers of the Technicians who were assigned to the project.

5. Submittals
   a. Submit name of the Balancing Sub-Sub Contractor for approval within 30 days after award of contract.
   b. Submit for review, prior to commencement of work, a list of equipment and procedures to be used in balancing the systems.
   c. Submit reports of preconstruction plan check and periodic mechanical construction review.
   d. Submit draft copies of report for review prior to final acceptance of project. Provide final copies to the Designer and for inclusion in operating and maintenance manuals.
6. Procedures, General
   a. All Air and Hydronic Systems shall be balanced using a procedure which results in minimum restrictions being imposed.
      1) At Completion of balancing:

a) At least one damper for an outlet/inlet shall be fully open on every branch duct.
b) At least one branch duct balancing damper shall be fully open on every trunk duct.
c) At least on trunk (zone) balancing damper shall be fully open in each Air System.
d) Supply/exhaust fan RPM shall be set so the static pressure at the terminal which is most difficult to supply/exhaust is adequate, but not excessive.
e) At least one hydronic terminal unit balancing valve in each piping branch shall be fully open.
f) At least one branch line balancing valve in each Hydronic System shall be fully open.

7. Final Reports
   a. Submit reports on previously approved Test Data Forms
   b. Forms shall include the following information:
      1) Title Page:
         a) Company name
         b) Company address
         c) Company telephone number
         d) Name, signature, and registration number of each technician
         e) Project name
         f) Project location
         g) Project Architect
         h) Project Engineer
         i) Project Contractor
         j) Project altitude
         k) Date of report
      2) Instrument List:
         a) Instrument
         b) Manufacturer
         c) Model
         d) Serial number
         e) Range
         f) Calibration date
      3) Air Moving Equipment
         a) Designation
         b) Location
         c) Manufacturer
         d) Model
         e) Airflow, specified and actual
         f) Return airflow, specified and actual
         g) Outside airflow, specified and actual
         h) Total static pressure (total external), specified and actual
         i) Inlet pressure
         j) Discharge pressure
         k. Fan RPM
      4) Return\ Exhaust Fan Data:
         a) Designation
         b) Location
         c) Manufacturer
         d) Model
         e) Airflow, specified and actual

f) Total static pressure (total external), specified and actual
g) Inlet pressure
h) Discharge pressure
i) Fan RPM, initial and final

5) Electric Motor:
   a) Manufacturer
   b) HP
   c) Frame
   d) Phase, voltage, amperage; nameplate and actual
   e) RPM
   f) Service factor
   g) Starter size, rating, heater elements
6) V-Belt Drive:
   a) Identification
   b) Driven sheave, diameter
   c) Belt, size and quantity
   d) Motor sheave, diameter
   e) Center to center distance, maximum, minimum, and actual
   f) Final components
7) Duct Traverse:
   a) System zone/branch
   b) Duct size
   c) Area
   d) Design velocity
   e) Design airflow
   f) Test velocity
   g) Test airflow
   h) Duct static pressure
   i) Air temperature
   j) Air correction factor
8) Air Monitoring Station Data:
   a) Identification/location
   b) System
   c) Size
   d) Area
   e) Design velocity
   f) Design airflow
   g) Test velocity
   h) Test airflow
9) Air Distribution Test sheet:
   a) Air terminal number
   b) Room number/location
   c) Terminal type
   d) Terminal Size
   e) Area factor
   f) Design velocity
   g) Design airflow
   h) Test velocity, initial and final
   i) Test airflow, final
   j) Percent of design airflow, initial and final
10) VAV Terminal Data:
   a) Designation
   b) Location

c) Manufacturer
d) Type
e) Model
f) Size
g) Design airflow
h) Actual airflow
i) Design Water Flow
j) Actual Water Flow

11) Cooling Coil Data:
a) Designation
b) Location
c) Service
d) Manufacturer
e) Size, face area, and fins/inch
f) Airflow, design and actual
g) Entering Air DB temperature, design and actual
h) Entering air WB temperature, design and actual
i) Leaving air DB temperature, design and actual
j) Leaving air DB temperature, design and actual
k) Air pressure drop, design and actual

12) Heating Coil Data:
a) Designation
b) Location
c) Service
d) Manufacturer
e) Size, face area, and fins/inch
f) Airflow, design and actual
g) Water flow, design and actual
h) Water pressure drop, design and actual
i) Entering water temperature, design and actual
j) Leaving water temperature, design and actual
k) Entering air temperature, design and actual
l) Leaving air temperature, design and actual
m) Air pressure drop, design and actual.

13) Heating Terminal, Pump, HX and Radiation Data:
a) Designation
b) Location
c) Service
d) Manufacturer
e) Size and fins/inch
f) Water flow, design and actual
g) Water pressure drop, design and actual
h) Temperature in and out (HX only)
i) Pump pressure and flow

c. Report is to include a listing of any abnormal or notable conditions not contained in the above.
d. Provide four copies of reports in soft cover, letter size, 3-ring binder manuals, complete with index page and indexing tabs, with cover identification at front and side. Include set of reduced drawings with air outlets and equipment identified to correspond with data sheets, and indicating thermostat locations.

8. HVAC Sub-Contractor Responsibilities
a. Prepare each system for testing and balancing

b. Cooperate with Balancing Sub-Sub Contractor, provide access to equipment and systems. Operate systems at designated times, and under conditions required for proper testing, adjusting, and balancing.
c. Notify Balancing Sub-Sub Contractor seven days prior to time system will be ready for testing, adjusting, and balancing.
d. Where fans (air handling units, supply fans, return fans, exhaust fans, etc.) are provided with variable pitch sheaves, HVAC Sub-Contractor shall adjust sheaves, as required, at no additional cost to the Owner, until desired Design Points (CFM and/or Static Pressure) are reached. If adjustment of the variable pitch sheaves is beyond the range of the sheaves, HVAC Sub-Contractor shall replace sheaves, as required, at no additional cost to the Owner, until the desired Design Points (CFM and/or Static Pressure) are reached. Where fans (air handling, supply, return, exhaust, etc.) are specified with fixed ratio sheaves, HVAC Sub-Contractor shall replace sheaves with new sheaves, at no additional cost to the Owner until desired Design Points (CFM and/or Static Pressure) are reached.

9. Sequencing and Scheduling
   a. Sequencing work to commence after completion of systems and schedule completion of work before Substantial Completion of Project.
10. Drawing and Construction Review
   a. Perform a pre-construction review of the following documents:
      1) Contract drawings.
      2) Contract specifications.
      3) Addenda.
      4) Submittal data.
      5) Shop drawings.
      6) Automatic Control drawings.
   b. Prepare a report of the preconstruction review list of recommended changes to allow most effective balancing.
   c. Perform two construction reviews of the mechanical installation during the progress of the project. Purpose of the reviews to be:
      1) Identify potential problems for performing balancing.
      2) Identify modifications which will aid balancing.
      3) Schedule and coordinate balancing with other work.
   d. Prepare a report of each construction review.
11. Equipment
   a. Provide all necessary tools, scaffolding and ladders.
   b. Provide all necessary instruments. Instruments shall be used and applied which are best suited to the system function being tested. Instruments shall be in first class state of repair and have been calibrated within a period of six months prior to starting the job. Calibration history of each instrument shall be available for examination. Instruments shall be re-calibrated upon completion of the job if required by the Designer to prove reliability.
12. Examination
   a. Before commencing work, verify that systems are complete and operable. Ensure the following:
      1) Equipment is operable an in safe and normal condition.
      2) Temperature control systems are installed complete and operable.
      3) Proper thermal overload protection is in place for electrical equipment.
      4) Final filters are clean and in place. If required, install temporary media in addition to final filters.
      5) Duct systems are clean of debris.
      6) Correct fan rotation.

7) Fire and volume dampers are in place and open.
8) Coil fins have been cleaned and combed.
9) Access doors are closed and duct end caps are in place.
10) Air outlets are installed and connected.
11) Duct system leakage has been minimized.
12) Proper strainer baskets are clean and in place.
13) Correct pump rotation.
14) Hydronic systems have been flushed, filled, and vented.
15) Service and balance valves are open.

b. Report to the Designer any defects or deficiencies noted during performance of services.
c. Promptly report abnormal conditions in mechanical systems or conditions which prevent system balance.
d. If, for design reasons, system cannot be properly balanced, report as observed.
e. Beginning of work means acceptance of existing conditions.

13. Preparation
a. Provide instruments required for testing adjusting and balancing operations. Make instruments available to the Designer to facilitate spot checks during testing.

14. Installation Tolerances
a. Adjust Air Handling Systems to the following tolerances:
1) Supply systems shall be balanced so that:
a) The total quantity to each space is within -5% to +10% of design values.
b) If two outlets in space, each outlet is within -10% to +10% of design value.
c) If three or more outlets in space, each outlet is within -15% to +15% of design value.
2) Exhaust and return systems shall be balanced so the total quantity from each space is -10% to +10% of design values.
b. Adjust Hydronic Systems to the following tolerances:
1) Heating System:
a) Supply water temperature above 160°F: -10% to +10% of design value.

15. Adjusting
a. Recorded data shall represent actually measured or observed condition.
b. Permanently marked settings of valves, dampers, and other adjustment devices, allowing settings to be restored. Set and lock memory stops.
c. After adjustment, take measurements to verify balance has not been disrupted or that such disruption has been rectified.
d. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, and restoring thermostats to specified settings.

16. Air System Procedure
a. Measure and balance air quantities at air inlets an outlets.
b. Adjust Air Handling and Distribution Systems to provide design supply, return and exhaust air quantities at site altitude.
c. Make air quantity measurements in ducts by pitot tube traverse of entire cross sectional area duct.
d. Adjust distribution system to obtain uniform space temperatures free from objectionable drafts and noise.
e. Effect volume control at outlets by use of dampers installed in the ductwork. Do not use volume dampers that are integral with the outlets.

f. Measure static air pressure conditions on air supply units, including filter and coil pressure drops, and total pressure across the fan. Make allowances for 50 percent loading of filters.

g. Adjust outside air automatic dampers, outside air, return air, and exhaust dampers for design conditions.

h. Measure temperature conditions across outside air, return air, and exhaust air dampers to check leakage.

i. Where modulating dampers are provided, take measurements and balance at extreme conditions. Set variable volume terminals at maximum airflow rate, full cooling with design diversity; read volumes at minimum airflow rate and full heating.

j. Measure building static pressure and adjustable supply, return and exhaust air systems to provide required relationship between each to maintain approximately 0.05 inches positive static pressure near the building entries.

17. Water System Procedure
    a. Adjust water systems to provide design quantities.
    b. Use calibrated flow meters and pressure gages to determine flow rates for system balance. Where flow metering devices are not installed, base flow balance on temperature difference across various heat transfer elements in the system.
    c. Adjust systems to provide specified pressure drops and flows through heat transfer elements prior to thermal testing. Perform balancing by measurement of temperature differential in conjunction with air balancing.
    d. Effect system balance with automatic control valves fully open to heat transfer elements.
    e. Effect adjustment of water distribution systems by means of balancing cocks, valves, and fittings. Do not use service or shut-off valves for balancing unless indexed for balance point.
18. Field Verification
    a. The Designer may request verification of the data contained in the Balancing Report. If so, the TAB Technician who originally initialed the data sheets shall read outlets selected at random by the Designer who will compare the values with those in the report.
    b. It is understood that the verification process shall take place within one week after delivery of the report. The operating mode of the system shall be the same for verification as it was during the balancing procedure.
    c. The number of readings to be verified shall not exceed 10% of the total contained in the report.
    d. If the field verification is not satisfactory, the firm doing the TAB work shall completely rebalance the system and a new report shall be prepared. The Designer may notify the Sheet Metal Industry Certification Board for TAB Technicians so that appropriate action can be taken.

B. It shall be division 23.00.00 responsibility to provide all personnel as required to fully coordinate with the commissioning agent as applicable. The hours of training and instruction outlined in division 23.00.00 and the Testing and Balancing requirements shall be in addition to those tests and requirements outlined in the commissioning section as applicable.

C. Certified Reports

1. For the reports required to be submitted within this section, provide certification by an independent balancing and testing contractor who is versed in the field of air balancing and who is not affiliated with any firm involved in the design or construction phases of this work.

2. Identify in the reports each item not complying with the Contract requirements, or obvious misoperation or design deficiencies of equipment or controls.

D. Additional Commissioning Coordination & Requirements

1. The Testing, Adjusting, & Balancing (TAB) Balancing Contractor shall submit their TAB procedures as part of the SUBMITTAL criteria in Division 1 of this specification. Integral with this submittal shall be the TAB strategy/plan for water system, which shall include the following
   a. Furnish one-line, schematic system drawings for the Commissioning Agent review of the Hot Water Piping System.
2. Each hydronic system drawing will be 1-line schematic representation of the system to be they are installed, indicating all coils, balancing valves, strainers, automatic control valves, pressure regulating valves, meters, etc.
3. Each hydronic system flow diagram shall indicate all pressure drops (design conditions and actual conditions) of each component, as well as associated flows and temperatures (design and actual).
4. Furnish one-line, schematic system drawings for the Commissioning Agent review of the Duct System for the follows:
   a. Central HVAC system(s)
   b. General exhaust system(s)
5. Each air system drawing will be 1-line schematic representation of the system to be they are installed, indicating all louvers, dampers, filters, coils, fans, dampers, balancing valves, volume terminal devices, etc.
6. Each air system flow diagram shall indicate all pressure drops (design conditions and actual conditions) of each component, as well as associated flows, velocity, and temperatures (design and actual)

E. NFPA 72 Testing

1. The HVAC contractor shall assist the electric contractor in performing the required NFPA 72 testing of devices effecting HVAC systems such as duct smoke detectors, smoke dampers and fire/smoke dampers. In addition, after one year from date of substantial completion or from first accepted NFPA 72 test, whichever is the later, the HVAC Trade Contractor shall assist the electric contractor in re-performing the required NFPA 72 testing of the related devices for recertification.

3.06 LABELING

A. Provide pipe markers of either pressure sensitive tape or laminated plastic, color coded and indicating the type and direction of flow of the piping service. Duct labels shall be stenciled and painted on the ductwork. All heating supply and return water, glycol supply & return water, refrigeration piping (Vapor & Liquid), cold (domestic) water feeding HVAC systems and condensate drain piping throughout the building shall be labeled. All piping containing

electric heat trace under insulation must be labeled as containing such. All supply, return and exhaust ductwork mains shall be labeled with flow direction, service and associated air moving unit. Ducts and piping excluded from the labeling requirement are any of the following: 1) Ducts exposed within finished spaces, 2) Branch ducts downstream of a VAV, 3) branch ducts serving individual VAV, diffuser, register or grille. Labels shall be at the inlet and outlet to each piece of equipment, at the entrance and exit of each room and at intervals along the duct and pipe of a minimum of every 20 feet.

B. All equipment, starters and VFD's shall be labeled with engraved laminated nametags with lettering of at least 1.5" in height. For roof mounted Chillers, RTU's and AHU's Provide laminated lettering on top and side of each unit identifying "RTU-# or AHU-# or CH-#". Minimum letter size shall be 6" high however, obtain approval from Fire Department for exact lettering, color and size requirements. In addition, each piece of equipment shall include a laminated tag with a QR code linked to a master database containing submittal and O&M data on the piece of equipment. Contractor shall coordinate with the project CM and the City of Worcester in providing the data required to establish this database.

C. 1-1/2" Brass valve tags with recessed stamped black lettering indicating service and valve number shall be provided at every shut-off, bypass and control valve in the building. Shut-off valves at individual VAV's, cabinet heaters and baseboard heaters located within 5 feet of the serviced terminal need not be tagged. A typed valve chart shall be made and inserted in each copy of the operation and maintenance. In addition, the valve chart shall be mounted in a glass frame affixed to a wall in the boiler room. Chart shall show valve number, valve type and valve service. Directions for system seasonal drain down or isolation of components shall be included on this chart.

3.07 PAINTING

A. Equipment installed under this Section shall have shop coat of factory applied non-lead paint, unless otherwise specified. Touch-up any scratches with matching paint. Hangers and supports shall have one coat of non-lead primer.

3.08 SPARE STOCK

A. It is the intent of this specification that all equipment requiring or specified with air filters be furnished with two (2) spare sets of filters (both pre and final) for each piece of equipment in addition to those supplied with the unit and after flush-out. Presuming the unit has not been operated during construction (operation during construction only allowed with written approval from Architect) the set of filters initially installed in the unit shall be utilized during testing and balancing and building flush out. After flush out, a new set of air filters shall be installed leaving the Owner with two (2) full spare sets. All pre-filters shall have a minimum efficiency of MERV 8 and all final filters and single filter units shall have a minimum efficiency of MERV 13.

All RTU, AHU and MAU filter sections must be fitted with differential pressure gauges viewable from the outside of the unit. Gauges shall be connected to EMS where specified elsewhere in this specification.

B. Belts & Spare Stock:

It is the intent of this specification that all equipment requiring or specified with belt drives (i.e. fans, energy recovery wheels in RTU's, AHU's, MAU's exhaust fans, etc…) be

furnished with two (2) spare sets of belts for each piece of equipment in addition to those supplied with the unit.

In addition, any items considered consumable or required for routine maintenance and service replacement within the first 18 months of an equipment's operation shall be supplied of adequate quantity to operate the equipment for a period of 24 months.

C. Thermostats:

Furnish twelve (12) spare thermostats or each type.

D. Consumables and Other Spare Stock:

Any items considered consumable or required for routine maintenance and service replacement within the first 18 months of an equipment's operation shall be supplied of adequate quantity to operate the equipment for a period of 24 months. This shall include but not be limited to boiler ignitors and other items required for routine maintenance/replacement in equipment with the first 18 months of operation.

END OF SECTION 23 00 00

Section 26 00 01

ELECTRICAL

(TRADE CONTRACT REQUIRED)

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 TIME, MANNER AND REQUIREMENTS FOR SUBMITTING SUB-BIDS:

A. Sub-bids for work under this Section shall be for the complete work and shall be filed in a sealed envelope with the City of Worcester, Department of Public Works and Parks, Architectural Division, 50 Skyline Drive, Worcester, MA 01605 at time and place stipulated in the “Invitation to Bid/Notice to Contractors”. The following shall appear on the upper left hand of the envelope:

Name of Sub-Bidder: *Print Name of Sub-bidder*
Project: _____
Sub-Bid for Section: 260001 – ELECTRICAL

B. Each sub-bid submitted for work under this Section shall be on forms furnished by the City of Worcester as required by Section 44F of Chapter 149 of the General Laws, as amended. Sub-Bid forms may be obtained at the Department of Public Works and Parks, Architectural Division, 50 Skyline Drive, Worcester, MA 01605 in person, or by written request.

C. Sub-bids filed with the City of Worcester shall be accompanied by a BID BOND or CASH or CERTIFIED CHECK or a TREASURER’S or CASHIER’S CHECK issued by a responsible bank or trust company payable to the City of Worcester in the amount of five (5) percent of the bid. A sub-bid accompanied by any other form of bid deposit than those specified will be rejected.

D. Additional Requirements:

1. Sub-bidder's attention is directed to Massachusetts G.L. Chapter 149 §44H, as amended, which provides in part as follows:
2. Each sub-bidder shall list in Paragraph E of the "Form for Sub-bids" the name and bid price of each person, firm or corporation performing each class of work or part thereof for which the Section of the Specifications for that sub-subtrade requires such listing, provided that, in the absence of a contrary provision in the Specifications, any sub-bidder may, without listing any bid price, list his own name or part thereof and perform that work with persons on his own payroll, if such sub-bidders, after sub-bid openings, shows to the satisfaction of the Awarding Authority that he does customarily perform such class of work with persons on his own payroll and is qualified to do so. This Section of the Specifications requires that the following classes of work shall be listed in Paragraph E under the conditions indicated herein.

Class of Work	Reference Specification
Charging Stations	
Electric Vehicle Charging Station	26 27 29
Solar Photovoltaic System	
Photovoltaics	26 31 05
Photovoltaics Data Acquisition System	26 31 10
Lightning Protection System	
Lightning Protection for Structures	26 41 13
Theatrical Lighting	
Theatrical Lighting Controls and Fixtures	26 50 00
Field Lighting	
Exterior Athletic Field Lighting	26 56 68
Telecommunications Infrastructure	
Communications Backbone Cabling	27 13 00
Communications Horizontal Cabling	27 15 00
Testing of Fiber Infrastructure	27 17 10
Testing Category 6A Twist Pair Infrastructure	27 12 20
Audio-Video Systems	
Audio-Video Communications	27 41 00
Integrated Audiovisual Systems	27 41 16
Communications	
Data Communications Network Equipment	27 21 00
Area of Refuge System	27 30 00
Voice Communications Equipment	27 31 00
In-Ceiling Instructional Audio System	27 41 20
In-Building Cellular Amplification System	27 50 00
Handheld Radio Amplification System	27 50 10
Public Address System	27 51 16
Digital Signage and Clock System	27 51 29
Public Safety Radio DAS	27 53 19

Security System

Unified Security System	28 10 00

Fire Alarm System

Addressable Fire-Alarm System	28 31 11

E. The work done by this sub-bidder is shown on the following drawings:

1. The work of this Trade Contract is shown on the following drawings:

E0.1, E0.2, E0.3, E0.3A, E0.4, E0.5, E0.6, E0.7, E0.8, E0.11, E0.12, E1.1, E1.2, E1.3, E1.4, E1.5, E1.6, E1.7, E1.8, E1.9, E1.10, E1.11, E1.12, E1.13, E1.14, E1.15, E1.16, E1.17, E1.18, E1.19, E2.1, E2.2, E2.3, E2.4, E2.5, E2.6, E2.6A, E2.6B, E2.6C, E2.7, E2.8, E2.9, E2.10, E2.11, E2.12, E2.13, E2.14, E2.15, E2.16, E2.17, E2.18, E3.1, E3.2, E3.3, E3.4, E3.5, E3.6, E3.7, E3.8, E3.9, E3.10, E3.11, E3.12, E3.13, E3.14, E3.15, E3.16, E3.17, E3.18, E3.19, E3.20, E4.0, E4.1, E4.2, E4.3, E4.4, E4.5, E4.6, E5.0A, E5.0B, E5.0C, E5.0D, E5.0E, E5.0F, E5.0G, E5.0H, E5.0I, E6.0A, E6.0B, E6.0C, E6.0D, E7.1, E7.2, E7.3, E8.1, E8.2, E9.00, E9.01, E9.02, E9.03, E9.04, E9.05, E9.06, E9.07, E9.08, E9.09, E9.10, E9.11, E9.12, E9.13, E9.14, E9.15, E9.16, E9.17, E9.18, E9.19, E9.20, E9.21

FA0.1, FA0.2, FA1.1, FA1.2, FA1.3, FA1.4, FA1.5, FA1.6, FA1.7, FA1.8, FA1.9, FA1.10, FA1.11, FA1.12, FA1.13, FA1.14, FA1.15, FA1.16, FA1.17, FA1.18, FA2.1A, FA2.1B, FA2.1C, FA2.1D, FA2.1E, FA3.0, FA4.0, FA5.0A, FA5.0B

TC0.1, TC1.1, TC1.2, TC1.3, TC1.4, TC1.5, TC1.6, TC1.7, TC1.8, TC1.9, TC1.10, TC1.11, TC1.12, TC1.13, TC1.14, TC1.15, TC1.16, TC1.17, TC1.18, TC2.1, TC2.2, TC2.3, TC2.4, TC2.5, TC2.6, TC3.1A, TC3.1B, TC3.1C, TC3.2A, TC3.2B, TC3.2C, TC3.2D, TC3.3A, TC3.3B, TC3.3C, TC3.3D, TC3.4A, TC3.4B, TC3.4C, TC3.5A, TC3.5B, TC3.6, TC3.7A, TC3.7B, TC3.8A, TC3.8B, TC3.8C, TC3.8D, TC4.0

AV1.0, AV1.1, AV1.2, AV3.3, AV3.4, AV3.6, AV3.8, AV3.10, AV3.14, AV3.20, AV4.1, AV6.1, AV6.2, AV6.3, AV7.1, AV7.2, AV7.3, AV8.0, AV8.1, AV8.2, AV8.3, AV8.4, AV8.5, AV8.6,

TL3.4, TL3.12, TL3.20, TL4.1, TL4.2, TL6.1, TL6.2, TL9.0, TL9.1, TL9.2, TL9.3, TP1, TR3.4, TR3.12, TR4.1, TR5.10, TR6.1

PV001, PV002, PV101, PV102, PV103, PV104, PV201, PV301, PV302, PV303, PV304, PV401, PV501, PV502, PV503, PV504, PV505, PV601, PV602, PV603, PV604, PV605.

2. Related items which may require coordination or impact work of this trade are shown on the following Drawings:

EX1.0, EX2.0, EX3.0, EX4.0, C1.0, C1.1, C1.2, C2.0, C2.1, C2.2, C3.0, C3.1, C3.2, C4.0, C4.1, C4.2, C5.0, C5.1, C5.2, C6.0, C6.1, C6.2, C6.3, C7.0, C7.1 C7.2, C8.0, C8.1, C8.2, C9.0, C9.1, C9.2, C9.3, C10.0, C10.1, C10.2, C10.3, C10.4, C10.5, L0.0, L0.1, L0.2, L1.1, L1.2, L1.3, L1.4, L1.5, L2.1, L2.2, L2.3, L2.4, L2.5, L2.6, L3.1, L3.2, L3.3, L3.4, L3.5, L4.1, L4.2, L4.3, L4.4, L4.5, L4.6, L4.7, IR-1, IR-2, IR-3, S1.01, S1.02, S1.03, S3.01, S3.02, S3.03,

S3.04, S3.05, S3.06, S3.07, S3.08, S3.09, S3.10, S3.11, S3.12, S3.13, S3.14, S3.15, S3.16, S3.17, S3.18, S3.19, S3.20, S3.21, S3.22, S4.01, S4.02, S4.03, S4.04, S4.05, S4.06, S4.07, S4.08, S4.09, S4.10, S4.11, S4.12, S4.13, S4.14, S4.15, S4.16, S4.17, S4.18, S4.19, S4.20, S4.21, S4.22, S4.23, S4.24, S4.25, S4.26, S4.27, S4.50, S4.51, S4.52, S4.53, S4.54, S4.55, S5.01, S5.02, S5.03, S5.04, S5.11, S5.12, S5.13, S5.14, S5.15, S5.16, S5.17, S5.18, S5.19, S5.20, S6.01, S7.01, S7.02, AD1.0, A1.0, A1.1, A1.2, A1.3, A1.4, A1.5, A1.6, A1.7, A2.0, A2.1, A2.2, A2.3, A2.4, A2.5, A2.6, A3.1, A3.2, A3.3, A3.4, A3.5, A3.6, A3.7, A3.8, A3.9, A3.10, A3.11, A3.12, A3.13, A3.14, A3.15, A3.16, A3.17, A3.18, A3.19, A3.20, A3.21, A3.22, A4.1, A4.2, A4.3, A4.4, A4.5, A4.6, A4.7, A4.8, A4.9, A4.10, A4.11, A4.12, A4.13, A4.14, A4.15, A4.16, A4.17, A5.0, A5.1, A5.2, A5.3, A5.4, A5.5, A5.6, A5.7, A5.8, A5.10, A5.11, A5.12, A5.13, A5.14, A5.15, A6.1, A6.2, A6.3, A6.4, A6.5, A6.6, A6.7, A6.8, A6.9, A6.10, A6.11, A6.12, A6.13, A6.14, A6.15, A6.16, A6.17, A6.18, A6.20, A6.21, A6.22, A6.23, A6.24, A6.25, A6.26, A6.27, A6.28, A6.29, A6.30, A6.32, A6.33, A7.0, A7.1, A7.2, A7.3, A7.4, A7.5, A7.6, A7.7, A7.8, A7.9, A7.10, A7.11, A7.12, A7.13, A8.1, A8.2, A8.3, A8.4, A8.5, A8.6, A8.7, A8.8, A8.9, A8.10, A8.11, A8.12, A8.13, A8.14, A8.15, A8.16, A8.17, A8.18, A8.18A, A8.19, A8.20, A8.21, A8.22, A8.22A, A8.23, A8.23A, A8.24, A8.24A, A8.25, A8.26, A8.27, A8.28, A8.30, A8.31, A8.32, A8.33, A8.34, A8.35, A8.36, A8.37, A8.38, A8.39, A8.41, A8.42, A8.43, A8.44, A8.45, A8.46, A9.0, A9.1, A9.2, A9.3, A9.4, A9.5, A10.1, A10.2, A10.3, A10.4, A10.5, A10.6, A11.1, A11.2, A11.3, A11.4, A11.5, A12.1, A12.2, A12.3, A12.4, A12.5, A12.6, A12.7, A12.8, A12.9, A12.10, A12.11, A12.12, A12.13, A12.14, A12.15, K1.1, K1.2, K2.1, K2.2, K2.3, K2.4, K3.1, K3.2, K4.1, K4.2, K4.3, K4.4, K5.1, K5.2, K6.1, K6.2, K6.3, FP-1.0, FP-1.1, FP-1.2, FP-1.3, FP-1.4, FP-4.1, FP-4.2, FP-4.3, FP-4.4, FP-4.5, FP-4.6, FP-4.7, FP-4.8, FP-4.9, FP-4.10, FP-4.11, FP-4.12, FP-4.13, FP-4.14, FP-4.15, FP-4.16, FP-4.17, FP-4.18, P2.1, P2.2, P2.3, P2.4, P3.1, P3.2, P3.3, P3.4, P3.5, P3.6, P3.7, P3.8, P3.9, P3.10, P3.11, P3.12, P3.13, P3.14, P3.15, P3.16, P3.17, P3.18, P3.19, P3.20, P3.21, P4.1, P4.2, P4.3, P4.4, P4.5, P4.6, P4.7, P4.8, P4.9, P4.10, P4.11, H3.1, H3.2, H3.3, H3.4, H3.5, H3.6, H3.7, H3.8, H3.9, H3.10, H3.11, H3.12, H3.13, H3.14, H3.15, H3.16, H3.17, H3.18, H3.19, H3.20, H3.21, H3.22, H4.1, H4.2, H4.3, H4.4, H4.5, H4.6, H4.7, H4.8, H4.9, H4.10, H4.11, H4.12, H4.13, H4.14, H4.15, H4.16, H4.17, H4.18, H5.1, H5.2, H5.3, H5.4, H5.5, H5.6, H6.1, H6.2, H6.3, H6.4, H6.5, H6.6, H7.1, H7.2, H7.3, H7.4, H7.5, H7.6, H7.7

3. The complete List of Drawings for the Project is provided in Section 00 01 15.
4. Examine all Drawings and all other Sections of the Specifications for requirements therein affecting the work of this Section The listing of Contract Drawings above does not limit Trade Contractor's responsibility to determine full extent of work of this Section by all Drawings listed in the Drawing List on the Drawing Title Sheet, as modified by Addenda.

1.3 DESCRIPTION OF WORK

A. The work of this section is work of a Publicly Bid Electrical Subcontractor and includes the following requirements:

1. Specification requirements for the Trade Contract "ELECTRICAL WORK" include all of the following listed Specification Sections in their entirety:
   a. 26 00 01 Electrical
   b. 26 05 00 Common Work Results for Electrical
   c. 26 05 13 Medium-Voltage Cables
   d. 26 05 19 Electrical Power Conductors and Cables
   e. 26 05 26 Grounding and Bonding for Electrical Systems
   f. 26 05 29 Hangers and Supports for Electrical Systems
   g. 26 05 33 Raceway and Boxes for Electrical Systems
   h. 26 05 48 Vibration and Seismic Controls for Electrical Systems
   i. 26 05 53 Identification for Electrical Systems
   j. 26 05 73 Overcurrent Protective Device Coordination Study

k. 26 09 13 Electrical Power Monitoring and Control
l. 26 09 43 Network Lighting Controls
m. 26 12 19 Pad-Mounted, Liquid-Filled, Medium-Voltage Transformers
n. 26 22 00 Low Voltage Transformers
o. 26 24 13 Switchboards
p. 26 24 16 Panelboards
q. 26 24 19 Motor Controls
r. 26 25 20 Generator Docking Station
s. 26 27 26 Wiring Devices
t. 26 27 29 Electrical Vehicle Charging Station
u. 26 28 13 Fuses
v. 26 28 16 Enclosed Switches and Circuit Breakers
w. 26 31 05 Photovoltaics
x. 26 31 10 Photovoltaics Data Acquisition System
y. 26 32 13 Engine Generators
z. 26 33 53 Static Uninterruptible Power Supply
aa. 26 36 00 Transfer Switches
bb. 26 41 13 Lightning Protection for Structures
cc. 26 50 00 Stage and House Lighting and Controls
dd. 26 51 00 Interior Lighting
ee. 26 56 00 Exterior Lighting
ff. 26 56 68 Exterior Athletic Field Lighting
gg. 27 05 00 Common Work Results for Communications
hh. 27 13 00 Communications Backbone Cabling
ii. 27 15 00 Communications Horizontal Cabling
jj. 27 17 10 Testing of Fiber Infrastructure
kk. 27 12 20 Testing Category 6A Twist Pair Infrastructure
ll. 27 21 00 Data Communications Network Equipment
mm. 27 30 00 Area of Refuge System
nn. 27 31 00 Voice Communications Equipment
oo. 27 41 00 Audio-Video Communications
pp. 27 41 16 Integrated Audiovisual Systems
qq. 27 41 20 In-Ceiling Instructional Audio System
rr. 27 50 00 In-Building Cellular Amplification System
ss. 27 50 10 Handheld Radio Amplification System
tt. 27 51 16 Public Address System
uu. 27 51 29 Digital Signage and Clock System
vv. 27 53 19 Public Safety Radio DAS
ww. 28 10 00 Unified Security System
xx. 28 31 11 Addressable Fire-Alarm System

B. Alternates: Special attention is called to the fact that it shall be the responsibility of all the General and Subcontractors to thoroughly examine all the alternates and evaluate for themselves as to whether or not these alternates in any way affect their respective section. In the event that a Contractor feels that any alternate(s) do reflect a cost difference, additional or a deduction in his bid proposal, then he shall so stipulate this sum and/or sums under the proper alternate(s) as provided for the bid proposals. Failure to do so will in no way relieve the hereinbefore stated contractors of their responsibilities regardless of what alternate(s) are selected at no extra cost will be charged to the Owner. Refer to Section 01 23 00, ALTERNATES for the list and description of Alternates.

C. Items to Be Installed Only: Install the following items as furnished by the designated Sections:

1. Division 8 – OVERHEAD COILING DOORS:
   a. Controllers, wiring and power connections for overhead coiling doors.

2. Division 8 – HOLD OPEN DEVICE:
   a. Controllers, wiring and power connections for hold open devices.

3. Division 10 – VIDEO DISPLAY BOARDS:
   a. Controllers, wiring and power connections for video display boards.
   b. TV/monitor in the lobby.

4. Division 11 – PROJECTION SCREENS:
   a. Controllers, wiring and power connections for electrically operated projection screens.

5. Division 11 –SCREENS, CURTAINS, BACKBOARDS AND SCOREBOARDS:
   a. Controllers, wiring and power connections for electrically operated projection screens, curtains, backboards, and scoreboards.

6. Division 12 – FURNISHINGS:
   a. Power and telecommunications connections for casework, including boxes and wiring devices.

7. Division 21 – FIRE PROTECTION:
   a. Connections to fire alarm system for water flow switches and tamper switches.

8. Division 22 – PLUMBING:
   a. Power connections for:
      1) Water heaters, hand dryers, automatic flush, and faucets.
      2) Gas Sniffers.
      3) Gas Shut offs.
         a) Coordinate electrical shutoffs in the kitchen. If kitchen is supplied with naturals gas, coordinate with gas shutoffs such that both gas and electric services are shut off with the same push button.
         b) Coordinate electrical shutoffs in the labs. Coordinate with gas shutoffs such that both gas and electric services are shut off with the same push button.
         c)
         d) Coordinate shutoffs in shops, shutoffs must require reset by the instructor with a code, or key, including under power failure such that machines cannot come on-on their own.

9. Division 23 – HEATING, VENTILATING AND AIR CONDITIONING:
   a. Power connections for control panels, pumps, fans, electric unit heaters, boilers, VAVs.

10. Division 31 – EARTH WORK:
    a. Anchor bolts and conduit sweeps for light pole bases.

D. Items to Be Furnished Only: Furnish the following items for installation by the designated Sections:

1. Division 3 – CAST-IN-PLACE CONCRETE:
   a. Lintels, sleeves, anchors, inserts, plates, and similar items for electrical systems.

2. Division 4 – UNIT MASONRY:
   a. Access doors in masonry openings.

3. Division 9 – GYPSUM BOARD ASSEMBLIES:
   a. Access doors in gypsum board assemblies.

4. Division 9 – TILING:
   a. Access doors in tile.

5. Division 9 – ACOUSTICAL PANEL CEILINGS:
   a. Access doors in acoustical tile

6. Division 23 – HEATING, VENTILATING AND AIR CONDITIONING:
   a. Duct smoke detectors and sampling tubes.

E. Related Work: The following items are not included in this Section and will be performed under the designated Sections:

1. Section 01 60 00 – PRODUCT REQUIREMENTS: Owner's proprietary products and requirements for the same.
2. Division 3 – CAST-IN-PLACE CONCRETE for interior concrete equipment pads and installation of backboxes and conduit for electrical devices and light fixtures.
3. Division 5 – STRUCTURAL STEEL FRAMING for structural supports necessary to distribute loading from equipment to roof or floor.
4. Division 6 – ROUGH CARPENTRY for plywood backing panels.
5. Division 7 – FIRESTOPPING for coordination of floor and wall penetrations.
6. Division 8 – DOOR HARDWARE for coordination with electrified door hardware.
7. Division 9 – GYPSUM BOARD ASSEMBLIES for coordination with gypsum ceilings.
8. Division 9 – ACOUSTICAL PANEL CEILINGS for coordination with acoustical ceilings.
9. Division 22 – PLUMBING for coordination with sensors located at plumbing fixtures.
10. Division 23 – HEATING, VENTILATING AND AIR CONDITIONING for coordination with HVAC piping and ductwork, motors, and control wiring except 120 VAC power to control panels as indicated on the Drawings.
11. Division 31 – EARTH MOVING for excavation and backfilling for underground work.

F. Commissioning: The Electrical systems will be commissioned by an independent commissioning agent (CxA). This sub-contractor shall review all commissioning requirements outlined in Sections 01 91 13 (GENERAL COMMISSIONING REQUIREMENTS) and 01 43 25 (TESTING AGENCY SERVICES), and shall provide all commissioning task labor and documentations, attend all required meetings, and provide all on-site assistance required by the CxA to properly complete their work.

G. Refer to the Construction Managers Supplemental Instructions to bidders , section 00 73 00, Project Phasing Requirements Section 01 12 00, for summary of partial work that has been completed, and this contractor's coordination and work responsibilities for the remaining scope, briefly summarized as follows:

1. Primary electric manholes along the access drive were installed under the earlier site phase.
2. Foundation grounding wire was installed and bonded to the reinforcing steel and is coiled for connection under this scope.
3. Some foundation sleeves and penetrations have been installed. All other foundation penetrations are to be core drilled under this work scope.
4. Interior foundation walls will be waterproofed and backfilled to approximately 36" below upper floor level, deeper excavations for conduit runs will not be permitted.
5. Temporary power and data/telephone has been installed part way on the site, including Transformer, a shed was installed for temporary switchgear , and further connections to be installed under this contract.

H. The Electrical Sub-Contractor shall be responsible for filing all documents, payment of all fees, and securing of all inspections and approvals necessary for the electrical work.

I. The Owner shall be responsible for all Utility Company and Municipal back charges for all materials furnished and work performed by them in conjunction with this Contract and pay same to the respective agency upon demand.

1.4 EXAMINATION OF SITE AND DOCUMENTS

A. Bidders are expected to examine and to be thoroughly familiar with all contract documents and with the conditions under which work will be carried out. The Awarding Authority (Owner) will not be responsible for errors, omissions and/or charges for extra work arising from General Contractor or Filed Subcontractor's failure to familiarize themselves with the Contract Documents or existing conditions. By submitting a bid, the Bidder agrees and warrants that he has had the opportunity to examine the site and the Contract Documents, that he is familiar with the conditions and requirements of both and where they require, in any part of the work a given result to be produced, that the Contract Documents are adequate and that he will produce the required results. Pre-Bid Conference: Bidders are strongly encouraged to attend the Pre-Bid conference; refer to INVITATION TO BID for time and date.

B. Pre-Bid Conference: Bidders are strongly encouraged to attend the Pre-Bid conference; refer to Invitation to Bid for time and date.

1.5 REFERENCES

A. Except where modified by a specific notation to the contrary, it shall be understood that the indication and/or description of any electrical item in the drawings or specifications for electrical work carries with it the instruction to furnish, install and connect the item as part of the electrical work, regardless of whether or not this instruction is explicitly stated.

B. It shall be understood that the specifications and drawings for electrical work are complimentary and are to be taken together for a complete interpretation of the electrical work. Where the specifications and drawings for electrical work conflict with each other the costlier item will take precedence over the less costly unless the Designer rules otherwise.

1.6 REGULATORY REQUIREMENTS

A. Comply with all applicable federal and state laws, and all local codes, by-laws, and ordinances.

B. Where provisions of the Contract Documents conflict with any codes, rules or regulations, the latter shall govern. Where the contract requirements are in excess of applicable codes, rules or regulations, the contract provisions shall govern unless the Designer rules otherwise.

C. Request inspections from authorities having jurisdiction, obtain all permits and pay for all fees and inspection certificates as applicable and/or required. All permits and certificates shall be turned over to the Owner at the completion of the work. Copies of permits shall be given to the Owner prior to the start of work.

D. Unless otherwise specified or indicated, materials and workmanship and equipment performance shall conform with the latest edition of the following standards, codes, specifications, requirements, and regulations:

1. State Building Code
2. State Electrical Code
3. National Fire Protection Association (NFPA)

4. Local Town Regulations and By-laws
5. Underwriter's Laboratories, Inc. (UL)
6. National Electrical Manufacturer's Association (NEMA)
7. American National Standards Institute (ANSI)

E. All electrical work shall meet or exceed any other state and local codes and/or authorities having jurisdiction including all other standards indicated herein.

1.7 QUALITY ASSURANCE

A. Company specializing in work described in the above listed individual specification sections with minimum 5 years documented experience.

B. The requirements of the State Building Code and local regulations establish the minimum acceptable quality of workmanship and materials, and all work shall conform thereto unless more stringent requirements are indicated or specified herein.

C. All work shall comply with the latest editions of the codes as referenced herein.

D. Follow manufacturer's directions for articles furnished, in addition to directions shown on drawings or specified herein.

E. Protect all work, materials, and equipment from damage during process of work. Replace all damaged or defective work, materials, and equipment without additional cost to the Owner.

F. All equipment and materials for permanent installation shall be the products of recognized manufacturers and shall be new.

G. Equipment and materials shall:

1. Where normally subject to Underwriters Laboratory Inc. listing or labeling services, be so listed or labeled.
2. Be without blemish or defect.
3. Not be used for temporary light and power purposes.
4. Be in accordance with the latest applicable NEMA standards.
5. Be products which will meet with the acceptance of all authorities having jurisdiction over the work. Where such acceptance is contingent upon having the products examined, tested, and certified by Underwriters or other recognized testing laboratory, the product shall be so examined, tested and certified.

H. Except for conduit, conduit fittings, outlet boxes, wire and cable, all items of equipment or material of one generic type shall be the product of one manufacturer throughout.

I. For items which are to be installed but not purchased as part of the electrical work, the electrical work shall include:

1. The coordination of their delivery.
2. Their unloading from delivery trucks driven into any point on the property line at grade level.
3. Their safe handling and field storage up to the time of permanent placement in the project.
4. The correction of any damage, defacement, or corrosion to which they may have been subjected. Replacement if necessary, shall be coordinated with Contractor who originally purchased the item.
5. Their field make-up and internal wiring as may be necessary for their proper operation.

6. Their mounting in place including the purchase and installation of all dunnage, supporting members, and fastenings necessary to adapt them to architectural and structural conditions.
7. Their connection to building wiring including the purchase and installation of all termination junction boxes necessary to adapt and connect them to this wiring. Included also shall be the purchase and installation of any substitute lugs or other wiring terminations as may be necessary to adapt their terminals to the building wiring as called for and to the connection methods set forth in these specifications.

J. Items which are to be installed but not purchased as part of the electric work shall be carefully examined upon delivery to the project. Claims that any of these items have been received in such condition that their installation will require procedures beyond the reasonable scope of the electric work will be considered only if presented in writing within one week of the date of delivery to the project of the items in question. The electric work includes all procedures, regardless of how extensive, necessary to put into satisfactory operation, all items for which no claims have been submitted as outlined above.

1.8 SUBMITTALS

A. Comply with requirements specified in Division 1.

B. Material and equipment requiring Shop Drawing Submittals shall include but not be limited to:

1. Common Work Results for Electrical
2. Medium-Voltage Cables
3. Electrical Power Conductors and Cables
4. Grounding and Bonding for Electrical Systems
5. Hangers and Supports for Electrical Systems
6. Raceway and Boxes for Electrical Systems
7. Vibration and Seismic Controls for Electrical Systems
8. Identification for Electrical Systems
9. Overcurrent Protective Device Coordination Study
10. Electrical Power Monitoring and Control
11. Network Lighting Controls
12. Pad-Mounted, Liquid-Filled, Medium-Voltage Transformers
13. Low Voltage Transformers
14. Switchboards
15. Panelboards
16. Motor Controls
17. Generator Docking Station
18. Wiring Devices
19. Electrical Vehicle Charging Station
20. Fuses
21. Enclosed Switches and Circuit Breakers
22. Photovoltaic System
23. Engine Generators
24. Static Uninterruptible Power Supply
25. Transfer Switches
26. Lightning Protection for Structures
27. Stage and House Lighting and Controls
28. Interior Lighting
29. Exterior Lighting
30. Exterior Athletic Field Lighting
31. Common Work Results for Communications
32. Communications Backbone Cabling

33. Communications Horizontal Cabling
34. Testing of Fiber Infrastructure
35. Testing Category 6A Twist Pair Infrastructure
36. Data Communications Network Equipment
37. Area of Refuge System
38. Voice Communications Equipment
39. Audio-Video Communications
40. Integrated Audiovisual Systems
41. In-Ceiling Instructional Audio System
42. In-Building Cellular Amplification System
43. Handheld Radio Amplification System
44. Public Address System
45. Digital Signage and Clock System
46. Public Safety Radio DAS
47. Unified Security System
48. Addressable Fire-Alarm System

1.9 CONTRACT DRAWINGS AND SPECIFICATIONS

A. Drawings are diagrammatic and indicate the general arrangement of the various systems and approximate and relative locations of the materials and equipment defined by the specifications. Coordinate with and obtain the approval of the owner, architect, and engineer for the exact locations of all materials and equipment. Check the drawings, specifications, and all fabrication and shop drawings (including fabrication and shop drawings of other trades) to verify space conditions, headroom requirements, characteristics, and for coordination. Where space conditions and headroom requirements appear inadequate, notify the engineer before submitting a bid. No consideration or allowance will be granted for failure to notify the engineer, or for any alleged misunderstanding of the requirements above. Completely furnish, install, connect, and interconnect all components of all systems in accordance with contract requirements, manufacturer's instructions, applicable codes and standards, and best practices of the trade.

B. Minor deviations, variations, changes, and connections from layouts shown on the drawings (based on coordination, conditions, manufacturer's instructions, codes and standards, shop drawings, and verification of measurements and conditions) are permitted to facilitate construction provided the changes do not represent potential changes in scope of work (see the section of these specifications "Changes to the Scope of Work") and provided the changes are acceptable to the owner, architect, and engineer.

C. Before submitting bid, examine and check all drawings and specifications relating to all work, including electrical, mechanical, plumbing, general construction, fire protection, and any other trades' drawings and specifications (as well as Division 1 General Conditions) and become fully informed as to the extent and character of work required and its relation to the work of other trades. No consideration, claims, charges, or compensation will be granted for any alleged misunderstanding of the work to be performed, or the force and intent of these specifications.

D. Fully coordinate (prior to releasing doors and hardware) with the General Contractor to ensure that all doors to rooms housing new large electrical equipment swing open in the direction of egress and are equipped with proper "panic" hardware as per the NEC where applicable.

1.10 VISIT TO SITE

A. Before estimating work, visit the project site and verify all measurements and field conditions affecting the work. The contractor is fully responsible for the correctness of all measurements.

Submission of bid is considered evidence that this contractor has visited and examined the site. No consideration, claims, charges, or compensation will be granted for extra work as a result of the contractor's failure to visit the site or verify conditions and measurements.

1.11 SURVEYS AND MEASUREMENTS

A. Base all required measurements, both horizontal and vertical, on reference points established by the General Contractor and be responsible for the correct laying out of the electrical work. In the event of a discrepancy between actual measurements and those indicated, notify the General Contractor in writing, and do not proceed with the work required until written instructions have been issued by the General Contractor.

B. The Electrical Contractor is solely responsible for verifying field measurements, conditions, and drawing and specifications information (for all trades) before ordering materials and equipment and before commencing work. The Electrical Contractor is solely responsible for verifying shop drawings (including shop drawings of other trades) before releasing related materials and equipment and before rough in. No consideration, claims, charges, or compensation will be granted due to any differences between the actual dimensions and any dimensions indicated on the drawings.

C. Report any apparent discrepancies or conflicts found at once to the engineer for consideration and wait for a decision before proceeding with any work in the affected area.

D. The engineer's decisions in cases of discrepancies, conflicts, and related to verification of measurements and conditions are final and binding upon the Electrical Contractor, make all installation accordingly.

1.12 EXISTING CONDITIONS AND UTILITIES

A. Existing Conditions

1. Information and data indicated on the drawings regarding existing conditions (including underground utilities) is from the best available sources. However, no assurance is made as to completeness and/or accuracy.
2. Contact all utility companies operating in the project vicinity (water, gas, sewage, electric, telephone, cable television, etc.) and the owner's maintenance department (where applicable) and verify all existing underground systems before any excavation commences.
3. Relocate any existing underground electrical feeders and wiring in areas of construction and around proposed foundations as required. Include all costs in bid. If any third-party owned wiring or equipment interferes with construction, notify the engineer.

B. Demolition of Utilities

1. The electrical contractor shall be responsible for coordinating with utility company for disconnecting and making safe power to the existing building to facilitate demolition by the general contractor.

1.13 ITEMS NOT SHOWN OR SPECIFIED

A. Provide any items of material not indicated on the drawings and/or not specified, but which are required for the complete and proper installation and/or operation of any part of the work, as if indicated and specified.

B. Provide any work not indicated on the drawings and/or not specified, but which is required for compliance with applicable codes and regulations, as if indicated and specified.

C. No consideration, claims, charges, or compensation will be granted for performing work required for complete and proper installation/operation or required for compliance with applicable codes and regulations.

1.14 COORDINATION

A. Electrical Drawings are diagrammatic. They indicate general arrangements of electrical systems and other work. They do not show all offsets required for coordination nor do they show the exact routings and locations needed to coordinate with structure and other trades and to meet Architectural requirements.

B. Work shall be performed in cooperation with other trades on the project and so scheduled as to allow speedy and efficient completion of the work.

C. Furnish to other trades advance information on locations and sizes of all frames, boxes, sleeves, and openings needed for their work, and also furnish information and shop drawings necessary to permit trades affected by the work to install same properly and without delay.

D. In all spaces, prior to installation of visible material and equipment, including access panels, review Architectural Drawings for exact locations and where not definitely indicated, request information from Designer. Where the electrical work shall interfere with the work of other trades, assist in working out the space conditions to make satisfactory adjustments before installation. Without extra cost to the Owner, make reasonable modifications to the work as required by normal structural interferences. Pay the General Contractor for additional openings or relocating and/or enlarging existing openings through concrete floors, walls, beams and roof required for any work which was not properly coordinated. Maintain maximum headroom at all locations. All piping, duct, conduit, and associated components to be as tight to underside of structure as possible.

E. If any electrical work has been installed before coordination with other trades so as to cause interference with the work of such trades, all necessary adjustments and corrections shall be made by the electrical trades involved without extra cost to the Owner.

F. Where conflicts or potential conflicts exist and engineering guidance is desired, submit sketch of proposed resolution to Designer for review and approval.

G. Protect all materials and work of other trades from damage which may be caused by the electrical work and repair all damages without extra cost to the Owner.

1.15 MECHANICAL AND ELECTRICAL COORDINATION

A. HVAC Subcontractor shall furnish and install various electrical items relating to the HVAC equipment and control apparatus. The Electrical Subcontractor shall be required to connect power wiring to this equipment unless noted otherwise.

B. The HVAC and Electrical Subcontractors shall coordinate their respective portions of the work, as well as the electrical characteristics of the heating and ventilating equipment.

C. All power wiring and local disconnect switches will be provided by the Electrical Subcontractor for the line voltage power. All control and interlocking wiring shall be the responsibility of the HVAC Subcontractor.

D. 120V and above power wiring sources extended and connected to heating and ventilating control panels, transformers and switches shall be the responsibility of the Electrical Subcontractor. All low voltage thermostat, zone valve and any switch wiring shall be the responsibility of the HVAC Subcontractor.

E. Temperature control and equipment wiring shall be installed by the HVAC Subcontractor.

F. Pipe Tracing shall be furnished and installed by the specified subcontractor. Power connections shall be by the Electrical Subcontractor.

G. The Electrical Subcontractor will provide all magnetic starters and disconnect switches except those furnished as an integral part of packaged equipment.

H. The Electrical Contractor shall be responsible for reviewing submittals (provided by the General Contractor) of other trades prior to submitting electrical submittals, ordering, or installing any electrical equipment, conduit, wire, materials, etc. Review:

1. Mechanical equipment submittals.
2. Plumbing equipment submittals.
3. Fire protection equipment submittals.
4. Theatrical dimming and audio-video equipment submittals.
5. Kitchen equipment submittals.
6. Elevator submittals.
7. Media distribution and audio-video equipment submittals.
8. Intrusion detection and access control equipment submittals.
9. Video surveillance equipment submittals.
10. Public address/clock equipment submittals.
11. Owner supplied equipment submittals.

I. The Electrical Contractor must review and incorporate all the electrical loads and characteristics from all the shop drawings submittals of other trades as part of their submittals.

J. Where conflicts or potential conflicts exist, immediately refer the conflicts to the Architect and the engineer in writing for decision to prevent delay in installation of work.

1.16 MECHANICAL AND ELECTRICAL COORDINATION DRAWINGS

A. Refer to Division 1 – PROJECT MANAGEMENT, COORDINATION AND COMMISSIONING for coordination drawing requirements.

1.17 INSTALLATION REQUIREMENTS

A. The arrangement of all electrical work shown on the drawings is diagrammatic only and indicates the minimum requirements of the work. Conditions at the building including actual measurements shall determine the details of the installation. All work shall be laid out and installed so as to require the least amount of cutting and patching.

B. Check the Architectural plans and specifications before ordering any material and equipment. Any discrepancies shall be brought to the attention of the Designer for his determination prior to proceeding with the work.

1.18 TYPICAL DETAILS

A. Typical details where shown on the drawings shall apply to each and every item of the project where such items are applicable. They are not repeated in full on the drawings, which in many cases are diagrammatic only, but with the intention that such details shall be incorporated in full. Any alternate method proposed for use by the Electrical Subcontractor shall have the prior approval of the Designer.

1.19 SLEEVES, INSERTS

A. Furnish and install all sleeves, inserts, anchor bolts and similar items to be set into masonry or concrete, as required for mechanical and electrical work. Internal diameter of sleeve shall be 2" larger than the outside diameter of the pipe or insulation covered line passing through it.

B. The Electrical Subcontractor is responsible for coring and sleeving (as applicable) all penetrations of the structure required of their respective work. All penetrations through the structure shall be sealed air and watertight.

1.20 FIRESTOPPING

A. Fire-stopping of all rated wall, floor, and ceiling penetrations used by this trade-contractor for any work completed under this Section. See Section 07 84 13, Firestopping for required methods and procedures.

B. Walls requiring sound seal, noted w/ STC rating, including but not limited to: Classrooms, offices, media center, cafeteria, gymnasium, and music rooms (for sound control), and thru exterior walls (for water and air seal) to be sealed with non-combustible, water-proof material, as specified in Section 09 29 00 Gypsum Board, both sides of all penetrations.

C. The Electrical Trade Contractor shall be responsible for fire stopping all wall, floor and ceiling penetrations for the electrical work as required for all conduit, wiring, cabinets, panels, etc. Fire stopping materials shall be coordinated with the Construction Manager.

D. All conduit, wiring, cabinets, panels, etc. installed by the Electrical Subcontractor through acoustical partitions shall be sealed with an approved acoustical sealant, by the Electrical Subcontractor.

1.21 CORING, DRILLING

A. Refer to the requirements of Division 1. Core, cut, and/or drill all small holes 4 inches in diameter or less in walls and floors required for the installation of sleeves and supports for the electrical work. Penetration larger than 4 inches will be by the General Contractor.

1.22 CUTTING AND PATCHING

A. Comply with Division 01.

1.23 ACCESSIBILITY

A. Install all work such that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible.

B. Furnish all access panels appropriate to particular conditions, to be installed by trades having responsibility for the construction of actual walls, floors or ceilings at required locations.

1.24 SUPPLEMENTARY SUPPORTING STEEL

A. Provide all supplementary steelwork required for mounting or supporting equipment and materials.

B. Steelwork shall be firmly connected to building construction as required.

C. Steelwork shall be of sufficient strength to allow only minimum deflection in conformity with manufacturer's published requirements.

D. All supplementary steelwork shall be installed in a neat and workmanlike manner parallel to floor, wall and ceiling construction; all turns shall be made at forty-five and ninety degrees, and/or as dictated by construction and installation conditions.

E. All manufactured steel parts and fittings shall be galvanized.

1.25 TOOLS AND EQUIPMENT

A. Provide all tools and equipment required for the fabrication and installation of the mechanical and electrical equipment at the site.

1.26 PORTABLE AND DETACHABLE PARTS

A. The Electrical Contractor shall retain in their possession all portable and/or detachable parts and portions of materials, devices, equipment etc. necessary for the proper operation and maintenance of the electrical systems until final completion of the work, at which time they shall be handed over to the Owner.

1.27 RECORD DRAWINGS, PROJECT CLOSEOUT

A. Comply with requirements specified in Division 1 – CONTRACT CLOSEOUT.

B. This trade shall submit the record set for approval by the fire and building departments in a form acceptable to the departments, when required by the jurisdiction.

C. Drawings shall show record condition of details, sections, riser diagrams, control changes and corrections to schedules. Schedules shall show actual manufacturer and make and model numbers of final equipment installation.

1.28 OPERATING, INSTRUCTION AND MAINTENANCE MANUALS

A. Refer to Division 1 for submittal procedures pertaining to operating and maintenance manuals.

B. Each copy of the approved operating and maintenance manual shall contain copies of approved shop drawings, equipment literature, cuts, bulletins, details, equipment and engineering data sheets and typewritten instructions relative to the care and maintenance for the operation of the equipment, all properly indexed. Each manual shall have the following minimum contents:

1. TABLE OF CONTENTS

2. Introduction
   a. Explanation of manual and its purpose and use.
   b. Description of the electrical systems.
   c. Safety precautions necessary for equipment.
   d. Illustrations, schematics, and diagrams.
   e. Installation drawing.

3. Maintenance
   a. Maintenance and lubricating instructions.
   b. Replacement charts.
   c. Trouble shooting charts for equipment components.
   d. Testing instructions for each typical component.
   e. Two typed sets of instructions for ordering spare parts. Each set shall include name, price, telephone number and address of where they may be obtained.

4. Manufacturer's Literature
   a. The equipment for which shop drawings have been submitted and approved.

1.29 SERVICE CHARACTERISTICS

A. Primary Utility Voltage: 13.8kV

B. Secondary Building Voltage - High Level: 480/277V

C. Secondary Building Voltage - Low Level: 208/120V

D. All equipment and wiring shall be suitable for the applied voltage.

1.30 DELIVERY, STORAGE AND HANDLING

A. All materials for the work of this section shall be delivered, stored, and handled so as to preclude damage of any nature. Manufactured materials shall be delivered and stored in their original containers, plainly marked with the products' and manufacturer's name. Materials in broken containers or in packages showing watermarks or other evidence of damage, shall not be used, and shall be removed from the site.

1.31 TEMPORARY POWER AND LIGHTING

A. The Electrical Subcontractor shall furnish and install feeders of sufficient size from the Utility Company's power transformer and meter for the electric light and power requirements for the building while under construction and until the permanent feeders and related equipment have been installed and are in operation. Temporary lighting shall be based on a minimum of one watt per square foot covering each and every square foot of floor area in the building. Sufficient wiring, lamps, and outlets shall be installed to insure proper lighting in all rooms, space, stairwells, and corridors. Minimum sized lamp used shall be 100 watt. Where higher lighting intensities are required by Federal or State Standards of Laws or otherwise specified, the above specified wattage shall be increased to provide these increased intensities.

B. All necessary transformers, meters, cables, panelboards, switches, temporary lamp replacements and accessories required for the temporary light and power installation shall be provided by the Electrical Subcontractor.

C. The Electrical Subcontractor shall provide and maintain on each floor of the building, a feeder, or feeders of sufficient capacity for the requirements of the entire floor and he shall provide a sufficient number of outlets, located at convenient points, so that extension cords of not over 50 ft. in length will reach all work requiring temporary light or power.

D. The Electrical Subcontractor shall provide temporary connection to the elevator. Refer to Section 142424 “Holeless Hydraulic Elevators”.

E. The Electrical Subcontractor shall install and maintain the wiring and accessories for the offices of the General Contractor and the Owner as specified in Section 015000 “Temporary Facilities and Controls”.

F. All temporary electrical work shall meet the requirements of the National Electrical Code, the Local Utility Company, and all Federal Standards and Laws.

G. All temporary wiring and accessories thereto installed by the Electrical Subcontractor shall be removed after their purposes have been served.

H. The General Contractor will pay for the cost of electric energy consumed by himself and by all of his Subcontractors, unless otherwise indicated.

I. All lamps installed in permanent lighting fixtures and used for lighting during construction shall be replaced by the Electrical Subcontractor just prior to date of Use and Occupancy or Final Acceptance.

J. Provide and maintain, to the satisfaction of the local authorities having jurisdiction, all temporary lighting and power that may be required for safety purposes. The Electrical Subcontractor will be compensated by the General Contractor for any additional standby time, materials or equipment required by the General Contractor or other Subcontractors beyond the normal working hours, as defined above.

1.32 COMMISSIONING

A. Comply with requirements specified in Division 1.

1.33 TRAINING AND SERVICE

A. The Owner shall be thoroughly instructed in the use of for each type of system installed, as defined in the specifications by the system vendor.

B. The Owner shall be thoroughly instructed in the use and upkeep of the system, the training shall include routine maintenance and operational adjustments.

C. Final “as built” documentation must be available at the job site for all training sessions.

D. The Electrical Subcontractor shall provide training materials free from any copyright restrictions, and upon request from the Owner, furnish a reproducible set of these materials.

E. Instruction and training for the operation and routine maintenance of the system shall be provided at site, after final completion acceptance of the system, at a time mutually satisfactory to the Electrical Subcontractor and Owner.

F. The training shall include system(s) functional description and the proper adjustment procedure for every adjustment in the system(s).

G. The equipment will be made available by the Owner, after delivery and acceptance, for use in the instruction and training program. The Owner will provide space for the instruction and training. The Electrical Subcontractor shall provide the instructor(s) and all training materials.

H. The Electrical Subcontractor shall engage a qualified videographer to record each training module separately on digital, window's compatible DVD media. Include instructions and demonstrations, diagrams, and other visual aids. At the beginning of each training module, record chart containing learning objective and lesson outline.

1.34 WARRANTY

A. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

B. The warranty shall repair or replace defective materials, equipment, workmanship, and installation that develop within this period, promptly and to Owner's satisfaction and correct damage caused in making necessary repairs and replacements under warranty within Contract Price.

C. In addition to warranty requirements of Division 1 and of Subparagraph A above, obtain written equipment and material warranties offered in manufacturer's published data without exclusion or limitation, in Owner's name.

1. Upon receipt of notice from the Owner of failure of any part of the systems or equipment during the warranty period, the affected part or parts shall be replaced by this Contractor without any reimbursement.
2. Replace material and equipment that require excessive service during warranty period as defined and as directed by Designer.
3. Provide 24-hour service beginning on the date the project is accepted by the Owner, whether or not fully occupied, and lasting until the termination of the warranty period. Service shall be at no cost to the Owner. Service can be provided by this contractor or a separate service organization. Choice of service organization shall be subject to the Owner's approval. Submit name and a phone number that will be answered on a 24-hour basis each day of the week, for the duration of the service.
4. Submit copies of equipment and material warranties to the Owner before final payment.
5. At end of warranty period, transfer manufacturers' equipment and material warranties still in force to the Owner.
6. This Paragraph shall not be interpreted to limit the Owner's rights under applicable codes and laws and under this Contract.
7. Parts of this Specification may specify warranty requirements that exceed those of this Paragraph. Those paragraphs will govern.
8. Use of systems provided under this Section for temporary services and facilities shall not constitute Final Acceptance of work by the Owner and shall not initiate the warranty period.
9. Non-durable items, such as electric lamps, shall be replaced up to the date of acceptance, such that they shall have had no more than 100 hours use prior to this date.
10. Provide manufacturer's engineering and technical staff at site to analyze and rectify problems that develop during warranty period immediately. If problems cannot be rectified immediately to the Owner's satisfaction, advise the Owner in writing, describe efforts to rectify situation, and provide analysis of cause of problem. Designer will direct course of action.

PART 2 - PRODUCTS

2.1 SEQUENCING

A. Phasing: Refer to Section 01 10 00 - Summary, and Drawings for phasing and milestone completion requirements which affect the General Contractor's Work and the Work of this Filed Subcontract.

B. Coordinate work of this Filed Subcontract with that of other trades, affecting or affected by this work, and cooperate with the other trades as is necessary to assure the steady progress of work.

C. Do not order or deliver any materials until all submittals, required in the listed Specification Sections included as part of this Filed Subcontract, have been received and approved by the Architect.

D. Before proceeding with installation work, inspect all project conditions and all work of other trades to assure that all such conditions and work are suitable to satisfactorily receive the work of this Section and notify the Architect in writing of any which are not. Do not proceed further until corrective work has been completed or waived.

2.2 SCAFFOLDS, STAGING, AND OTHER SIMILAR RAISED PLATFORMS

A. General: Filed Subcontractors shall obtain required permits for, and provide scaffolds, staging, and other similar raised platforms, required to access their Work as specified in Section 01 50 00 - Temporary Facilities and Controls and herein.

1. Scaffolding and staging required for use by this Filed Subcontractor pursuant to requirements of Section 01 50 00 - Temporary Facilities and Controls shall be furnished, erected, maintained in a safe condition, and dismantled when no longer required, by this Filed Sub-Trade requiring such scaffolding.
2. Each Filed Subcontractor is responsible to provide, maintain and remove at dismantling, all tarpaulins and similar protective measures necessary to cover scaffolding for inclement weather conditions other than those required to be provided, maintained and removed by the General Contractor pursuant to MGL (Refer to Section 01 50 00 - Temporary Facilities and Controls and as additionally required for dust control).
3. Furnishing portable ladders and mobile platforms of all required heights, which may be necessary to perform the work of this trade, are the responsibility this Filed Subcontractor.
4. Enclose all exterior scaffolding outside of the construction fence with 8-foot-high plywood enclosure at end of each workday to prohibit access to the scaffolding by unauthorized individuals.

PART 3 - EXECUTION

NOT USED

End of Section

Section 26 05 00

COMMON WORK RESULTS FOR ELECTRICAL

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. Section Includes:

1. Sleeves for raceways and cables.
2. Sleeve seals.
3. Grout.
4. Common electrical installation requirements.

1.4 SUBMITTALS

A. Product Data: For sleeve seals.

PART 2 - PRODUCTS

2.1 SLEEVES FOR RACEWAYS AND CABLES

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral water stop, unless otherwise indicated.

C. Sleeves for Rectangular Openings: Galvanized sheet steel.

1. Minimum Metal Thickness:

a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and no side more than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches (1270 mm) and 1 or more sides equal to, or more than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

2.2 SLEEVE SEALS

A. Approved Manufacturers

1. Manufacturers
   a. Advance Products & Systems, Inc.
   b. Calpico, Inc.
   c. Metraflex Co.
   d. Or approved equal.

B. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

1. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
2. Pressure Plates: Carbon steel Include two for each sealing element.
3. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.3 GROUT

A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, non-staining, mixed with water to consistency suitable for application and a 30-minute working time.

2.4 RACEWAY SEALS

A. Where a raceway enters a building or structure from outside, it shall be sealed. Spare or unused raceways shall also be sealed. Sealants shall be identified for use with cable insulation, conductor insulation, bare conductor, shield, or other components.

B. Where a service raceway enters a building or structure from an underground distribution system, it shall be sealed in accordance with the NEC. Spare or unused raceways shall also be sealed. Sealants shall be identified for use with the cable insulation, shield, or other components.

C. Conduits or raceways through which moisture may contact live parts shall be sealed or plugged at either or both ends. Spare or unused raceways shall also be sealed. Sealants shall be identified for use with the cable insulation, conductor insulation, bare conductor, shield, or other components.

D. Where portions of a raceway or sleeve are known to be problem, as in cold storage areas of buildings or where passing from the interior to the exterior of a building, the raceway or sleeve shall be filled with an approved material to prevent the circulation of warm air to a colder section of the raceway or sleeve.

E. Cap empty conduits during construction to avoid water ingress into the building.

PART 3 - EXECUTION

3.1 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

A. Comply with NECA 1.

B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.

C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.

D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.

E. Right of Way: Give to piping systems installed at a required slope.

3.2 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

E. Cut sleeves to length for mounting flush with both surfaces of walls.

F. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.

G. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable, unless indicated otherwise.

H. Seal space outside of sleeves with grout for penetrations of concrete and masonry.

1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.

I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants".

J. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.

K. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

L. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

M. Sleeves shall be installed and properly secured at all points where pipes pass though masonry, concrete or wood. Do not cut the steel decking before the slab is poured. Provide core drilling after slab is poured and cured. Core openings shall have Link-Seal fire rated penetration closures. The referred sleeve option is thru the use of Hilti “Platform for Metal Deck Firestop Sleeve” model CFS-CID MD PLT, sized to fit piping.

3.3 SLEEVE-SEAL INSTALLATION

A. Install to seal exterior wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

End of Section

Section 26 05 13

MEDIUM-VOLTAGE CABLES

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. This section specifies the furnishing, installation, and connection of medium-voltage cables, indicated as cable or cables in this section, and medium-voltage cable splices and terminations.

1.4 APPLICABLE PUBLICATIONS

A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by designation only.

1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.
2. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the Work.

B. ASTM International:

1. ASTM B-3, B-8, and B-496 - American Society for Testing Materials.

C. NFPA 70 - National Electrical Code.

D. IEEE C2 - the NESC (National Electrical Safety Code).

E. ICEA Publication No. S-93-639 NEMA WC7 - Insulated Cable Engineers Association.

F. IEEE 48 - Test Procedures and Requirements for High-Voltage Alternating-Current Cable Terminations.

G. NEMA WC 8 - Ethylene-Propylene-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.

H. NETA – National Electrical Testing Association

I. Underwriters' Laboratories, Inc. (UL 1072).

1.5 SUBMITTALS

A. Submit in accordance with the following requirements:

1. Shop Drawings:
   a. Submit sufficient information to demonstrate compliance with drawings and specifications.
   b. Submit the following data for approval:
      1) Complete electrical ratings.
      2) Installation instructions.

2. Samples:
   a. After approval of submittal and prior to installation, Contractor shall furnish sample in accordance with Section 26 05 11, REQUIREMENTS FOR ELECTRICAL INSTALLATIONS.

3. Certifications:
   a. Factory Test Reports: Submit certified factory production test reports for approval.
   b. Field Test Reports: Submit field test reports for approval.
   c. Compatibility: Submit a certificate from the cable manufacturer that the splices and terminations are approved for use with the cable.
   d. Two weeks prior to final inspection, submit the following.
      1) Certification by the manufacturer that the cables, splices, and terminations conform to the requirements of the drawings and specifications.
      2) Certification by the Contractor that the cables, splices, and terminations have been properly installed and tested.
      3) Certification by the Contractor that each splice and each termination were completely installed in a single continuous work period by a single qualified worker without any overnight interruption.

4. Qualified Worker Approval:
   a. Qualified workers who install cables, splices, and terminations shall have a minimum of five years of experience splicing and terminating cables, including experience with the materials in the approved splices and terminations. Qualified workers who perform cable testing shall have a minimum of five year of experience performing electrical testing of medium-voltage cables, including the ability to understand, interpret test results and develop test report.
   b. Furnish satisfactory proof of such experience for each qualified worker who splices or terminates the cables.

1.6 FACTORY TESTS

A. Factory Tests shall be required.

B. Factory Tests shall be in accordance with the following requirement:

1. A representative sample of Medium-voltage cables from each lot shall be factory tested per NEMA WC 74 to ensure that there are no electrical defects in that specific lot of cable.

1.7 QUALITY ASSURANCE

A. All conductors and cable shall conform to ICEA standards. Cable warranty shall begin upon the date of cable installation acceptance. Each length of cable delivered to the job shall have a certified test report from the factory stating that the cable meets the minimum standards for cables of this type as established by ICEA. The test report shall also include month and year of manufacture which shall not exceed twelve (12) months prior to the delivery to the site. Copies of this report shall be delivered to the Owner's representative before the cable is installed.

B. Manufacturer's Qualifications: Company experienced in manufacturing Products specified in this Section with minimum of ten (10) years.

C. Cable Splicer & Terminator Qualifications:

1. Workers' Competency: Submit high voltage cable splicer certification of competency and experience 30 days before splices or terminations are made in high voltage cables. Splicer experience during the immediate past three years shall include performance in splicing and terminating cables of the types and classification being provided under this Contract. In lieu of a certification of competency, a Subcontractor may demonstrate the qualifications of a proposed cable splicer through formal training and relevant experience in splicing cables of the type and class under this Subcontract.
2. Before assigning cable splicer to work covered by this specification, the Contractor shall provide the Engineer with the names of the cable splicers to be employed, together with satisfactory proof that each splicer has had at least three years experience in splicing high-voltage cables and is experienced with the type and rating of cables to be spliced. In addition, each cable splicer may be required to make an approved dummy splice in the presence of the Project Manager in accordance with manufacturer's instructions, before the splicer is accepted to splice cable covered by this Specification.
3. Material for dummy splices shall be furnished by the Contractor.

D. Source Limitations: Obtain cables, grounding, terminations, and associated materials through one source. Limit the number of manufacturers selected as much as possible.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to the Authority Having Jurisdiction and marked for intended use.

F. Comply with IEEE C2 (NESC) and NFPA 70.

G. Comply with ASTM B3 and B8 for copper wiring, conductors, and cables.

H. NRTL (Nationally Recognized Testing Laboratory) Listing: Products shall be listed and labeled by a qualified testing agency acceptable to authorities having jurisdiction for electrical and fire safety.

1.8 SHIPMENT AND STORAGE

A. Cable shall be shipped on reels such that it is protected against physical, mechanical and environmental damage. Each end of each length of cable shall be hermetically sealed with manufacturer's end caps and securely attached to the reel.

B. Cable stored and/or cut on site shall have the ends turned down, and sealed with cable manufacturer's standard cable end seals, or field-installed heat-shrink cable end seals.

1.9 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers for Cables

1. Okonite.
2. Southwire.
3. General Cable.
4. Or approved equal.

B. Approved Manufacturers for Cable Terminations

1. Elastimold (Thomas & Betts).
2. 3M; Electrical Products Division.
3. Richards Manufacturing Co.
4. Or approved equal.

2.2 15KV CABLE

A. Cable Type: Single conductor, jacketed, 15KV rated, Type MV-105 approved for NEC applications.

B. Comply with UL 1072, AEIC CS 8, ICEA S-93-639/NEMA WC74, and ICEA S-97-682.

C. Conductor:

1. Material shall be annealed, uncoated, soft drawn copper in conformance with ASTM B-3.
2. The conductors stranding shall be Class B, concentric lay in accordance with ASTM B8 (compressed construction) or ASTM B496 (compact construction) if a slightly smaller cable diameter is needed.
3. Class B stranding per ASTM B-496.

D. Conductor Strand Screen/Shielding:

1. A semi-conducting shielding compound shall be applied by extrusion directly to the surface of the stranded conductor.
2. The semi-conducting material shall be compatible with the copper conductor and shall effectively bond to the insulation.
3. The semi-conducting shielding shall strip clean from the conductor for make-up of terminations and splices.

E. Conductor Insulation:

1. Discharge free, EPR insulation, color contrasted with strand and insulation screens.
2. The insulation material shall meet or exceed ICEA S-94-649, AEIC CS8, and CSA C68.5. It shall meet the electrical and physical requirements specified in Part 3, ICEA S-93-639.
3. Temperature Rating: 221 deg F (105 deg C) normal operation, 284 deg F (140 deg C) emergency overload operation, and 482 deg F (250 deg C) for short circuit conditions.
4. Voltage Rating: 15 kV
5. Insulation Thickness: 133 percent insulation level and insulated with a high quality, heat, moisture, impact, ozone, and corona resistant thermosetting EPR that is suitable for use in wet or dry locations, in underground conduit and duct systems, and direct buried applications.
6. The average insulation thickness shall be not less than 220 mils; the minimum thickness at any point shall not be less than 90 percent of the specified average thickness.

F. Insulation Screen/Shielding:

1. Extruded, semiconducting material meeting requirements of ICEA S-93-639/NEMA WC74 & S-97-682, and AEIC CS8. Substitution of a non-metallic semiconducting tape for the extruded covering is not acceptable.
2. Note: cables using the extruded energy suppression and stress control material for the strand screen may use the same semiconducting material for the 15kV insulation screen.
3. The extruded covering shall be at least 24 mils thick and shall be in intimate contact with the insulation. Covering shall be removable without damaging the insulation; leaving no residue that cannot be readily removed. Insulation screens must be clean stripping.

G. Copper Tape Shield

1. Bare copper tape 5 mils minimum shall be applied with a helical lap not less than 12.5% of its width.

H. Overall/Outer Jacket:

1. The cable shall have an overall sunlight resistant (UV) poly-vinyl chloride jacket
2. The overall jacket shall be free stripping.

I. Electrical and Physical Tests:

1. Qualification tests in compliance with Section B, AEIC CS8 are required for each shielded cable furnished.
2. All materials used in construction of the cables shall be tested in compliance with the application paragraphs of ICEA S-93-639.
3. All completed cables shall successfully pass the following tests prescribed in ICEA publication S-93-639 NEMA WC 74:
   a. Par. 6.5 - Aging.
   b. Par. 6.27 - Voltage.
   c. Par. 6.28 - Insulation Resistance.

d. Par. 6.29 - Partial Discharge Extinction (Corona) Level.
e. Par. 6.23 - Discharge Residence.

4. Test methods and frequency of tests (for tests in F-2 and F-3 above) shall be as prescribed in Part 6 ICEA S-93-639.

J. Cable Identification: The following information shall be indicated, by means of a surface legend printed in compatible ink of contrasting color, at intervals not to exceed 24 inches (600 mm) over the entire length of the cable:

1. Manufacturer's name.
2. Conductor material.
3. Conductor size.
4. Maximum rated voltage.
5. Insulation material.
6. Letter designating cable type.
7. Shielded or non-shielded.
8. Date of manufacture.

K. Shipment: The cable shall be shipped in continuous lengths. No cable splices are allowed. The shipment shall be made on carefully inspected non-returnable reels if possible. Cable ends shall be securely fastened to the reel using polypropylene rope ties. Metal ties shall not be used. Cable ends shall be completely sealed against moisture and contaminants. The cable on the reel shall be protected with plyboard or tekboard lagging held securely in place with steel banding.

L. Conductor and Shield Continuity: Each length of completed cable shall be tested for conductor and shield continuity. A simple continuity test can be accomplished by grounding the conductor at the source and checking for continuity from the end of each tap with an ohmmeter or with a battery and ammeter. See Sections 3.3 and 3.4 below.

M. Reports: Certified copies of Production Tests shall be furnished for each shipment of cable.

2.3 CABLE TERMINATIONS

A. General: Modular system, complying with IEEE 386, with disconnecting, single-pole, cable terminators (deadbreaks) with matching, stationary, plug-in, deadbreak-front terminals designed for cable voltage and for sealing against moisture. Elbow-type unit with 600-A continuous-current rating; designed for de-energized disconnecting and connecting; coordinated with insulation diameter, conductor size, and material of cable being terminated. Include test point on terminator body that is capacitance coupled.

B. Construction: 100% peroxide-cured construction includes insulation and conductive EPDM materials. Deadbreaks shall be fully shielded and submersible, rated 15/25KV and 600A minimum.

C. Deadbreaks shall be designed for use on solid dielectric cable (XLPE or EPR) with extruded semi-conducting shields and concentric neutral, with or without a jacket. Provide adapters as required for terminating tape shield and drain wire jacketed cables.

D. Deadbreaks shall be useable on any comparably rated bushing interface that meets the requirements of IEEE 386. All T-bodies, cable adapters, insulating plugs, and compression

connectors shall be designed to be interchangeable with those currently available from other major manufacturers that also meet the requirements of the IEEE 386 standard.

E. Minimum ratings of the fully assembled deadbreaks as follows:

1.	Standard Voltage Class, kV	15
2.	Max Rating Phase-to-Phase, kV	14.4
3.	Max Rating Phase-to-Ground, kV	8.3
4.	AC 60 Hz 1 Minute Withstand, kV	34
5.	DC 15 Minute Withstand, kV	53
6.	BIL and Full Wave Crest, kV	95
7.	Min Partial Discharge Extinction, kV	11
8.	Continuous Rating, A	600
9.	4 Hour Overload Rating, A	900
10.	Short Time Rating, kA	25.5

F. Easily connected or disconnected using standard hand tools and equipment in de-energized state.

G. Each deadbreak kit to be provided complete with:

1. Elbow connector housing
2. Copper compression connector/lug
3. Shear bolt connector/lug
4. Stud
5. Insulating plug with cap
6. Tube of lubricant
7. Cable adapter
8. Installation instructions
9. Crimp chart

2.4 CABLE SPLICES

A. Cable splices are not allowed. Run underground cables continuous between end termination points.

2.5 CIRCUIT LABELS

A. Manufacturers:

1. Almetek Industries, Type E-Z -Tag or equal.
2. Substitutions: Under provisions of Division 01 Section "General Requirements".

B. Description: Cable circuit labels shall be 1-1/2 (38 mm) high, polyethylene, with black on yellow characters, in a polyethylene holder, attached to the cable by two nylon self locking ties.

2.6 FIREPROOFING TAPE

A. Fireproofing tape shall be flexible, non-corrosive, self-extinguishing, arcproof, and fireproof intumescent elastomer. Securing tape shall be glass cloth electrical tape not less than 0.18 mm (7 mils) thick, and 19 mm (0.75 inch) wide.

PART 3 - EXECUTION

3.1 15KV CABLE INSTALLATION

A. Carefully protect cable from mechanical damage. Provide suitable mechanical protection for reels.

B. All medium voltage feeders serving campus building transformers and utility distribution equipment shall be provided within concrete encased ductbanks.

C. Pull cable directly from reels into the ducts. It may not be laid on the ground or otherwise handled for cutting or sorting. Pulling lubricant, UL-listed and compatible with the cable being pulled, as manufactured by IDEAL, Y-ER-EAS, or equal, shall be generously applied. Pulling tension (lbs) not to exceed 0.008 times the circular-mil cross-sectional area of the conductor. Cables shall not be pulled through more than one intermediate manhole on one pull. Cable ends shall be sealed against moisture after pulling. Pull ropes shall be non-metallic to prevent cutting of duct materials.

D. Pulling tension and side wall pressure shall not exceed the manufacturer's allowable values. Pulling tension shall be continuously monitored during a pull by use of a dynamometer. The dynamometer shall have been calibrated within a year of its use on the project. If the pulling tension or sidewall pressure is exceeded during a pull, the cable shall be considered damaged and shall be replaced by the Subcontractor.

E. Installation of Cables in Manholes and Handholes: Cable shall not be installed utilizing the shortest route but shall be routed along those walls providing the longest route and the maximum spare cable lengths. Cables shall be formed closely parallel to the walls, shall not interfere with duct entrances, and shall be supported on brackets and cable insulators, spaced at a maximum of four feet. In existing manholes and handholes where new ducts are to be terminated or where new cables are to be installed, the existing installation of cables, cable supports, and grounding shall be modified as required for a neat and workmanlike installation with cables properly arranged and supported.

F. Split wire-basket cable grips shall be used to restrain conductors in manholes, handholes, and pull boxes on downhill duct runs.

G. Splicing of cable within manholes is not allowed. Cables shall be continuous until terminations.

H. Maintain existing phase rotation of the system as required for all new sections of cables. Perform phase rotation verification in conjunction with Owner's staff.

3.2 CABLE TERMINATIONS

A. Cable terminations shall be per written Manufacturer instructions. The Contractor shall furnish for approval the manufacturer's termination procedures.

B. Terminating cables onto deadbreaks is a complex, precise, and time-consuming process requiring great care. Cable terminations shall only be done by a qualified contractor specializing in high-voltage splicing, terminations, and testing. Utilize experienced cable splicers having experience specified in the Quality Assurance article above. Follow written manufacturer instructions.

C. Grounding of Shielded Cables: Provide a No. 12 AWG or larger solid copper ground connection brought out of each deadbreak break termination in a watertight manner and grounded to the ground bus within the switch. Wire shall be trained to the sides of the enclosure in a manner to avoid interference with the working area.

D. The ground bus and bare copper-conductor ground wires shall be bonded to the new ground rods and grounds provided in manhole or vault.

3.3 15KV CABLE LABELING

A. 15KV circuits shall have each phase tagged (A, B, or C) at termination points and on either side of each splice in a manhole, using plastic tie-tags.

B. At each manhole, handhole or pull box, 15kV circuit labels, as shown on the drawings, shall be attached to each cable group. As the cable enters it shall be labeled to identify the source. As the cable leaves it shall be labeled to identify its destination. At approximately the center of the cable group it shall be identified with its feeder circuit designation.

3.4 15KV CABLE TESTING IMMEDIATELY AFTER INSTALLATION

A. Immediately after cables have been installed, the Contractor shall notify the Owner when the installation is available for testing. The Owner shall have a representative onsite to witness testing.

B. Each conductor shall be individually tested with other conductors grounded. Shields shall be grounded. Record all test results.

C. A shield continuity test shall be performed by the ohmmeter method. Record all ohmic values.

D. The Contractor shall produce a written record of tests and, upon completion of the project, assemble and certify a final test report no later than ten days after completion of the tests. The Owner shall receive three (3) copies of the final test report.

3.5 15KV CABLE TESTING AFTER END TERMINATION PREPARATION

A. Immediately after cables have been spliced and cable ends prepared for termination, but not connected to equipment, the Contractor shall notify the Owner when the installation is available for testing. The Owner shall have a representative onsite to witness testing.

B. Each conductor shall be individually tested with other conductors grounded. Shields shall be grounded.

C. A shield continuity test shall be performed by the ohmmeter method. The ohmic value shall be recorded.

D. The Contractor shall produce a written record of tests and, upon completion of the project, assemble and certify a final test report no later than ten days after completion of the tests. The Owner shall receive three (3) copies of the final test report.

3.6 FIREPROOFING

A. Cover all cable segments exposed in manholes and pullboxes with fireproofing tape.

B. Apply the tape in a single layer, wrapped in a half-lap manner, or as recommended by the manufacturer. Extend the tape not less than 25 mm (1 inch) into each duct.

C. At each end of a taped cable section, secure the fireproof tape in place with glass cloth tape.

3.7 CIRCUIT IDENTIFICATION OF FEEDERS

A. In each manhole and pullbox, install permanent identification tags on each circuit's cables to clearly designate the circuit identification and voltage. The tags shall be the embossed brass type, 40 mm (1.5 inches) in diameter and 40 mils thick. Attach tags with plastic ties. Position the tags so they will be easy to read after the fireproofing tape is installed.

3.8 ACCEPTANCE CHECKS AND TESTS

A. General:

1. Perform tests in accordance with the latest IEEE 400 and 400.2, manufacturer's recommendations, and as specified in this specification.
2. Contractor shall make arrangements to have tests witnessed by the Resident Engineer. Contractor shall proceed with tests only after obtaining approval from the Resident Engineer.

B. Visual Inspection: Perform visual inspection prior to electrical tests.

1. Inspect exposed sections of cables for physical damage.
2. Inspect shield grounding, cable supports, splices, and terminations.
3. Verify that visible cable bends meet manufacturer’s minimum bending radius requirement.
4. Verify installation of fireproofing tape and identification tags.
5. At the time of final acceptance, Contractor shall provide the Resident Engineer visual field inspection notes, findings, and photographs detailing accessible inspection locations.

C. Cable tests are performed under electrical power shutdown condition. Contractor shall request and schedule electrical power shutdown to accommodate the tests.

D. Electrical Tests - New Cables: Perform preparation and tests in order shown below:

1. Preparation Prior to Testing: Splices and terminations applied to new cables shall be completed prior to testing. For renovation installation, ends of new cables intended to be spliced to existing service-aged cables shall be prepared (cut back) to allow testing without flashover or tracking. Cables shall not be connected to other equipment while under test.
2. Perform Insulation-Resistance Test. Test all cables with respect to ground and adjacent cables. All adjacent cables shall be grounded during testing.
   a. Apply test voltage for a period sufficient to stabilize output voltage and insulation resistance measurement.
   b. Test data shall include megohm, applied test voltage, and leakage current readings.

c. Further testing shall not continue unless the insulation resistance test results meet or exceed the values listed below. Test voltages and minimum acceptable resistance values shall be:

Voltage Class	Test Voltage	Min. Insulation Resistance
5kV	2,500 VDC	1,000 megohms
15kV	2,500 VDC	5,000 megohms
25kV	5,000 VDC	20,000 megohms
35kV	15,000 VDC	100,000 megohms

3. Perform Tan Delta test. Review and verify test readings are within acceptable range prior to proceeding with the Very Low Frequency (VLF) Withstand test
4. Perform Very Low Frequency (VLF) Withstand test. Utilize test voltages in accordance with IEEE 400.2.

E. Electrical Tests - Service-Aged Cables: Tests shall be performed for serviced-age cables before inter-connecting to new cables. Perform tests in order shown below:

1. Preparation Prior to Testing: Splices and terminations applied to cables shall be completed prior to testing. Ends of cables intended to be spliced to existing service-aged cables shall be prepared (cut back) to allow testing without flashover or tracking. Cables shall not be connected to other equipment while under test.
2. Perform Insulation-Resistance Test. Test all cables with respect to ground and adjacent cables. All adjacent cables shall be grounded during testing.
   a. Apply test voltage for a period sufficient to stabilize output voltage and insulation resistance measurement.
   b. Test data shall include megohm, applied test voltage, and leakage current readings.
   c. Further testing shall not continue unless the insulation resistance test results meet or exceed the values listed below. Test voltages and minimum acceptable resistance values shall be:

Voltage Class	Test Voltage	Min. Insulation Resistance
5kV	2,500 VDC	1,000 megohms
15kV	2,500 VDC	5,000 megohms
25kV	5,000 VDC	20,000 megohms
35kV	15,000 VDC	100,000 megohms

3. Perform Tan Delta test. Review and verify test readings are within acceptable range prior to proceeding with the Very Low Frequency (VLF) Withstand test.
4. Perform VLF Withstand test. Utilize test voltages in accordance with IEEE 400.2.

F. Electrical Tests – Inter-connected New Cables and Service-Aged Cables: After successful Tan Delta and VLF Withstand testing of new cables and service-aged cables, perform final splicing inter-connecting between new and service-aged cables. Once new and service-aged cables are completely inter-connected, conduct Tan Delta and VLF Withstand tests for the entire inter-connected cable. Utilize maintenance test voltage for VLF Withstand testing.

G. Field Test Report: Submit a field test report that includes the following information:

1. Project Name, Location, Test Date.
2. Name of Technician and Company performing the test.
3. Ambient temperature and humidity at time of test.

4. Name, Model Number and Description of Test Equipment used.
5. Circuit identification, cable length, cable type and size, insulation type, cable manufacturer, service age (if any), voltage rating, description of splices or terminations.
6. Visual field inspection notes, findings, and photographs.
7. Insulation Resistance Test results:
   a. Test voltage.
   b. Measurement in Megohms.
   c. Leakage current.

8. Tan Delta results:
   a. Test voltage.
   b. Waveform (sinusoidal or cosine-rectangular).
   c. Mean Tan Delta at V0.
   d. Stability measured by Standard Deviation at V0.
   e. Differential Tan Delta.
   f. IEEE Condition Assessment Rating.

9. VLF Withstand results:
   a. Test voltage.
   b. Waveform (sinusoidal or cosine-rectangular).
   c. Pass/Fail Rating.

10. Conclusions. If any deficiency is discovered based on test results, provide recommendations for corrective action.

H. Final Acceptance: Final acceptance shall depend upon the satisfactory performance of the cables under test. No cable shall be put into service until all tests are successfully passed, and field test reports have been reviewed.

End of Section

Section 26 05 19

ELECTRICAL POWER CONDUCTORS AND CABLES

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. This Section includes the following:

1. Building wires and cables rated 600 V and less.
2. Connectors, splices, and terminations rated 600 V and less.
3. Sleeves and sleeve seals for cables.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Field quality-control test reports.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.6 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

2.2 CONDUCTORS AND CABLES

A. Approved Manufacturers

1. General Cable Technologies Corporation.
2. Southwire Incorporated.
3. American Insulated Wire Corp
4. Or approved equal.

B. Aluminum and Copper Conductors: Comply with NEMA WC 70.

1. Feeders and branch circuits rated less than 100A and greater than 1600A shall be copper unless otherwise noted.
2. Feeders and branch circuits rated 100A or greater and 1600A or less shall be aluminum unless otherwise noted.
3. Primary and secondary service cables shall be copper.

C. Conductor Insulation: 90 degree rated; Comply with NEMA WC 70 for THHN, THWN-2 and XHHW-2.

D. Multiconductor Cable: Comply with NEMA WC 70 for metal-clad cable, Type MC with ground wire.

E. Emergency System Feeders: Mineral-insulated, metal-sheathed cable, Type MI.

F. 2-hour Rated Fire Alarm Cable: Mineral-insulated, metal-sheathed cable, Type MI.

2.3 CONNECTORS AND SPLICES

A. Approved Manufacturers

1. AFC Cable Systems, Inc.
2. 3M; Electrical Products Division.
3. Tyco Electronics Corp.
4. Or approved equal.

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.4 METAL CLAD (MC) CABLE ASSEMBLY

A. Description

1. Metal clad cable assemblies shall consist of 2 or more insulated, current carrying copper conductors. The Metal-Clad Cable shall be UL Classified as a Through-Penetrating Product (XHLY) for use in One, Two or Three-Hour Through-Penetration Firestop

Systems {XHEZ). Assembly shall be suitable for use in cable trays in accordance with the NEC.

2. Current-Carrying Conductors: Soft annealed copper in compliance with the latest edition of ASTM B3 and/or B8.
3. Each separate circuit conductor shall have its own dedicated neutral conductor. The dedicated neutral conductor shall be white/grey with a continuous color stripe matching the color of its dedicated circuit conductor. Multi-wire branch circuits are not allowed.
4. Grounding/Bonding Conductor: Full sized bare aluminum bonding/grounding conductor, sized in accordance with Table 6,1 of UL1569, working in combination with the armor to create a low resistance ground path. Aluminum bonding/grounding conductor shall be cabled with the current-carrying conductors and shall be in intimate contact with the metal armor.
5. Insulated Equipment Grounding Conductor: The equipment ground shall be full-sized in accordance with Table 6.1 of UL 1569 and shall be soft-annealed copper in compliance with the latest edition of ASTM B3 and/or B8.
6. Insulated Conductor: The insulated conductor shall be Type THHN 90°C DRY with an extruded polypropylene protective covering. The Type THHN Insulated Conductor with protective covering shall be manufactured and tested in accordance with UL 83 and UL 1569.
7. Armor: A zinc coated galvanized steel armor shall be applied over the cabled wire assembly with an interlock in compliance with Section 13 of UL 1569.

B. Fittings

1. Fittings shall be UL listed and identified for use with metal clad interlocking armor ground.
2. Connectors shall be of steel or malleable iron and shall have saddle clamp to insure a tight termination of MC Cable to box.

2.5 HEALTH CARE FACILITIES ARMORED CABLE (HCF AC)

A. Description

1. Armor: Galvanized Interlocking Steel Strip (green striped).
2. Conductors: Solid Copper.
3. Conductor Insulation: THHN; Covering Moisture resistant Fire Retardant Paper Wrap
4. Maximum Temperature Rating: 90°C (dry).
5. Grounding: 16 AWG integral Bond Wire/ combination and insulated green copper grounding conductor .
6. Neutral Conductor: White 120/208V / Grey 480Y/277V.
   Maximum Voltage Rating: 600V.
7. References & Ratings
   a. UL 4, 83, 1479, 1581, 2556, File Reference E7330
   b. NEC® 250.118(8), 300.22(C), 392, 320, 517.13, 518, 645
   c. Federal Specification A-A–59544 (formerly J-C–30B)
   d. Meets all applicable OSHA and HUD Requirements
   e. Cable Tray Rated, install per NEC®
   f. UL Classified 1, 2, and 3 hour through (Fire) penetration product, R–14141
   g. Environmental Air-Handling Space Installation per NEC® 300.22(C)
   h. Made in USA of US and/or imported materials

B. Features and Benefits

1. Interlocking galvanized steel strip.
2. Easy to identify green armor.
3. Full size green insulated copper grounding conductor plus armor/bond wire.
4. combination provides redundant ground or isolated grounding capability.
5. UL classified for through-wall penetrations.
6. Made in USA of US and/or imported materials.

C. Applications

1. Branch circuits and feeders in areas of patient care in hospitals, nursing homes, outpatient facilities, dental offices, clinics and medical centers (other than hazardous anesthetizing locations), data processing systems, Places of Assembly, under raised floors, above suspended ceilings and in other environmental air-handling spaces, exposed or concealed, surface mounted or fished, any application approved for AC cable requiring an isolated or redundant ground Galvanized Steel Color-Coded Green.

2.6 MINERAL INSULATE (MI) CABLE 2-HOUR RATED

A. Description

1. The wiring cable shall be 2-hour fire-rated.
2. The wiring cable shall be listed in the UL Fire Resistance Directory.
3. Mineral Insulated wiring Type MI cable shall have:
   a. Description: ANSI/NFPA 70, Type MI
   b. Conductor: solid high conductivity copper
   c. Insulation Voltage Rating: 600 volts
   d. Cable Temperature Rating: 90 degrees C
   e. Termination Temperature Rating: 90 degrees C
   f. Insulation Material: magnesium oxide
   g. Sheath Material: seamless soft-drawn copper
   h. Fire Rating: complete cable system shall have a 2-hour fire rating as listed and classified by Underwriters Laboratories, Inc.

4. Contractor shall have a minimum of 10 years of experience in the installation of such systems.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

A. Feeders: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type XHHW-2, single conductors in raceway.

B. Exposed Feeders: Type THHN-THWN-2, single conductors in raceway.

C. Emergency System Feeders in non-corrosive copper or brass environments: Mineral-insulated, metal-sheathed cable, Type MI.

D. Emergency System Feeders direct-buried: Mineral-insulated, metal-sheathed cable, Type MI with an extruded outer polyolefin jacket to provide additional protection.

E. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN-THWN-2, single conductors in raceway.

F. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN-2, single conductors in raceway.

G. Exposed Branch Circuits, Including in Crawlspaces: Type THHN-THWN-2, single conductors in raceway.

H. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN-2, single conductors in raceway; Metal-clad cable, Type MC.

1. Furnish and install Type HCF AC in exam rooms and treatment rooms in the Health Clinic.

I. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN-2, single conductors in raceway.

J. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

K. Class 1 Control Circuits: Type THHN-THWN-2, in raceway.

L. Class 2 Control Circuits: Type THHN-THWN-2, in raceway; Metal-clad cable, Type MC.

M. Fire Alarm Circuits:

1. Initiating and signaling circuits originating and serving an evacuation zone: manufacturer recommended cabling in minimum 3/4” EMT raceway.
2. Initiating and signaling circuits originating outside an evacuation zone: mineral-insulated, metal-sheathed cable, Type MI to the first device in the evacuation zone; and manufacturer recommended cabling in minimum 3/4” EMT raceway thereafter.
3. Riser cables: mineral-insulated, metal-sheathed cable, Type MI.
4. Initiating and signaling circuits for stair and stair pressurization system devices: mineral-insulated, metal-sheathed cable, Type MI.

3.3 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.

B. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.

C. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.

E. Support cables according to Division 26 Sections "Hangers and Supports for Electrical Systems."

F. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."

G. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

H. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

1. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.

I. Wiring at Outlets: Install conductor at each outlet, with at least 12 inches (300 mm) of slack.

3.4 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

D. Cut sleeves to length for mounting flush with both wall surfaces.

E. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.

F. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.

G. Seal space outside of sleeves with grout for penetrations of concrete and masonry and with approved joint compound for gypsum board assemblies.

H. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and cable, using joint sealant appropriate for size, depth, and location of joint according to Division 07 Section "Joint Sealants."

I. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at cable penetrations. Install sleeves and seal with firestop materials according to Division 07 Section "Penetration Firestopping."

J. Roof-Penetration Sleeves: Seal penetration of individual cables with flexible boot-type flashing units applied in coordination with roofing work.

K. Aboveground Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeves to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

L. Underground Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between cable and sleeve for installing mechanical sleeve seals.

3.5 SLEEVE-SEAL INSTALLATION

A. Install to seal underground exterior-wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for cable material and size. Position cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.6 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07.

3.7 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and feeder conductors for compliance with requirements.
2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
3. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each splice in cables and conductors No. 3 AWG and larger. Remove box and equipment covers so splices are accessible to portable scanner.

C. Test Reports: Prepare a written report to record the following:

1. Test procedures used.
2. Test results that comply with requirements.
3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

D. Remove and replace malfunctioning units and retest as specified above.

End of Section

Section 26 05 26

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. This Section includes methods and materials for grounding systems and equipment.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Field quality-control test reports.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with UL 467 for grounding and bonding materials and equipment.

1.6 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers

1. Harger Lightning and Grounding
2. Burndy; Part of Hubbell Electrical Systems
3. ERICO International Corporation
4. Or approved equal

2.2 CONDUCTORS

A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.

B. Bare Copper Conductors:

1. Solid Conductors: ASTM B 3.
2. Stranded Conductors: ASTM B 8.
3. Tinned Conductors: ASTM B 33.
4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch (6 mm) in diameter.
5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
6. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.

2.3 CONNECTORS

A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.

1. Pipe Connectors: Clamp type, sized for pipe.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.4 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad; 3/4-inch by10 feet (19 mm by 3 m) in diameter.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Conductors: Install solid conductor for No. 8 AWG and smaller, and stranded conductors for No. 6 AWG and larger, unless otherwise indicated.

B. Underground Grounding Conductors: Install bare copper conductor, No. 2/0 AWG minimum. Bury at least 24 inches (600 mm) below grade.

C. Conductor Terminations and Connections:

1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
2. Underground Connections: Welded connectors, except at test wells and as otherwise indicated.
3. Connections to Ground Rods at Test Wells: Bolted connectors.
4. Connections to Structural Steel: Welded connectors.

3.2 EQUIPMENT GROUNDING

A. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:

1. Feeders and branch circuits.
2. Lighting circuits.
3. Receptacle circuits.
4. Single-phase motor and appliance branch circuits.
5. Three-phase motor and appliance branch circuits.
6. Flexible raceway runs.
7. Armored and metal-clad cable runs.
8. Computer and Rack-Mounted Electronic Equipment Circuits: Install insulated equipment grounding conductor in branch-circuit runs from equipment-area power panels and power-distribution units.

B. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

C. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.

D. Signal and Communication Equipment: For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.

1. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-2-by-12-inch (6-by-50-by-300-mm) grounding bus.
2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

E. Manholes and Handholes: Metal covers and other exposed conductive surfaces shall be bonded in accordance with NEC Article 250.92 if the conductors are service conductors, or in accordance with NEC Article 250.96(A) if the conductors are feeder or branch-circuit conductors.

3.3 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

B. Ground Rods: Drive rods until tops are 2 inches (50 mm) below finished floor or final grade, unless otherwise indicated.

1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating, if any.
2. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.

C. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance, except where routed through short lengths of conduit.

1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.

D. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

E. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.

F. Grounding for Lightning Protection System: Install 3/0 AWG copper grounding conductor from the ground rods, in conduit, to the building's main service ground busbar.

3.4 FIELD QUALITY CONTROL

A. Perform the following tests and inspections and prepare test reports:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at ground test wells.
   a. Measure ground resistance not less than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
   b. Perform tests by fall-of-potential method according to IEEE 81.

B. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity 500 kVA and Less: 10 ohms.
2. Power and Lighting Equipment or System with Capacity 500 to 1000 kVA: 5 ohms.
3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
4. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohms.

C. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

End of Section

Section 26 05 29

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. Section includes:

1. Hangers and supports for electrical equipment and systems.
2. Construction requirements for concrete bases.

1.4 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design supports for multiple raceways, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.

C. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

D. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.5 SUBMITTALS

A. Product Data: For steel slotted support systems.

B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following:

1. Trapeze hangers. Include Product Data for components.
2. Steel slotted channel systems. Include Product Data for components.
3. Equipment supports.

C. Welding certificates.

1.6 QUALITY ASSURANCE

A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.

1. Approved Manufacturers
   a. Cooper B-Line, Inc.; a division of Cooper Industries.
   b. Thomas & Betts Corporation.
   c. Unistrut; Tyco International, Ltd.
   d. Or approved equal.

2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
3. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.

4. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
5. Channel Dimensions: Selected for applicable load criteria.

B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

C. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

D. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.

E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

F. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
   a. Approved Manufacturers
      1) Hilti Inc.
      2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
      3) MKT Fastening, LLC.
      4) Or approved equal.

2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
   a. Approved Manufacturers
      1) Cooper B-Line, Inc.; a division of Cooper Industries.
      2) Empire Tool and Manufacturing Co., Inc.
      3) Hilti Inc.
      4) Or approved equal.

3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
6. Toggle Bolts: All-steel springhead type.
7. Hanger Rods: Threaded steel.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.

2.3 RACEWAY AND CABLE SUPPORTS HANGING FROM STRUCTURE

A. This trade contractor shall refer to “TYPICAL HANGER LOAD RESTRICTIONS at COMPOSITE SLABS and ROOF DECK” on drawing S1.03 for the following information:

1. Hanger load limitations including associated pipe sizes.
2. Metal roof deck notes.

B. This trade contractor shall design, furnish, and install all supplementary steel or Unistrut systems which shall be supported only by structural steel when hanger loads exceed limitations set forth in detail “TYPICAL HANGER LOAD RESTRICTIONS at COMPOSITE SLABS and ROOF DECK” on drawing S1.03.

C. “Sammy” hanger attachments are not permitted under any conditions.

PART 3 - EXECUTION

3.1 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.

C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted or other support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.

1. Secure raceways and cables to these supports with two-bolt conduit clamps.

D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch (38-mm) and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.2 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMT and RMC may be supported by openings through structure members, as permitted in NFPA 70.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
6. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.
7. To Light Steel: Sheet metal screws.
8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

F. The Electrical Subcontractor shall install all hangers and supports for electrical systems prior to fireproofing.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Comply with installation requirements in Division 05 Section "Metal Fabrications" for site-fabricated metal supports.

B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

C. Field Welding: Comply with AWS D1.1/D1.1M.

3.4 CONCRETE BASES

A. Concrete bases shall be provided by the general contractor.

B. The Electrical Subcontractor shall provide the anchor-bolt pattern to the General Contractor for installation of anchor bolts.

C. The Electrical Subcontractor shall provide to the General Contractor the layout of conduit and other materials that penetrate the equipment pads.

3.5 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).

B. Touchup: Comply with requirements in Division 09 painting Sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.

C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

End of Section

Section 26 05 33

RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

B. See Division 26 for exterior duct banks and manholes, and underground handholes, boxes, and utility construction.

1.4 SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Shop Drawings: For custom enclosures and cabinets. Include plans, elevations, sections, details, and attachments to other work.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

1.6 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 METAL CONDUIT AND TUBING

A. Rigid Steel Conduit: ANSI C80.1.

B. EMT: ANSI C80.3.

C. FMC: Zinc-coated steel.

D. LFMC: Flexible steel conduit with PVC jacket.

E. Fittings for Conduit (Including all Types and Flexible and Liquid tight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.

1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886.
2. Fittings for EMT: Steel, set-screw or compression type.

2.2 NONMETALLIC CONDUIT AND TUBING

A. RNC: NEMA TC 2, Type EPC-40-PVC, unless otherwise indicated.

B. LFNC: UL 1660.

C. Fittings for RNC: NEMA TC 3; match to conduit or tubing type and material.

D. Fittings for LFNC: UL 514B.

2.3 METAL WIREWAYS

A. Manufacturers

1. Cooper B-Line, Inc.
2. Hoffman.
3. Square D; Schneider Electric.
4. Or approved equal.

B. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 1 and Type 3R (exterior) unless otherwise indicated.

C. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: Hinged type.

E. Finish: Manufacturer's standard enamel finish.

2.4 NONMETALLIC WIREWAYS

A. Manufacturers

1. Hoffman.
2. Lamson & Sessions.
3. Carlon Electrical Products.
4. Or approved equal.

B. Description: PVC plastic, extruded and fabricated to size and shape indicated, with Snap-On cover and mechanically coupled connections with plastic fasteners.

C. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

2.5 SURFACE RACEWAYS

A. Surface Metal Raceways: Galvanized steel with Snap-On covers. Manufacturer's standard enamel finish in color selected by Architect.

1. Manufacturers
   a. Thomas & Betts Corporation.
   b. Walker Systems, Inc.; Wiremold Company (The).
   c. Wiremold Company (The); Electrical Sales Division.
   d. Or approved equal.

B. Surface Nonmetallic Raceways: Two-piece construction, manufactured of rigid PVC with texture and color selected by Architect from manufacturer's standard colors.

1. Manufacturers
   a. Panduit Corp.
   b. Walker Systems, Inc.; Wiremold Company (The).
   c. Wiremold Company (The); Electrical Sales Division.
   d. Or approved equal.

2.6 BOXES, ENCLOSURES, AND CABINETS

A. Sheet Metal Outlet and Device Boxes: NEMA OS 1.

B. Cast-Metal Outlet and Device Boxes: NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

C. Nonmetallic Outlet and Device Boxes: NEMA OS 2.

D. Metal Floor Boxes: Cast or sheet metal, fully adjustable, rectangular.

E. Nonmetallic Floor Boxes: Nonadjustable, round.

F. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

G. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, cast aluminum with gasketed cover.

H. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
2. Nonmetallic Enclosures: Plastic, finished inside with radio-frequency-resistant paint.

I. Cabinets:

1. NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:

1. Exposed Conduit: Rigid steel conduit.
2. Concealed Conduit, Above ground: Rigid steel conduit; EMT.
3. Underground Conduit outside the foundation wall: RNC, Schedule 80 PVC, direct buried. Convert nonmetallic conduit to rigid steel conduit before rising through earth.
4. Underground Conduit within building confines: RMC, direct buried or RNC, Schedule 80 PVC, direct buried. Convert nonmetallic conduit to rigid steel conduit before rising through earth.
5. Exposed or underground conduit to sewage ejector pump chamber: PVC coated rigid steel conduit.
6. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
7. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.

B. Indoors: Apply raceway products as specified below, unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed, Not Subject to Severe Physical Damage: EMT.
3. Exposed and Subject to Severe Physical Damage: Rigid steel conduit. Includes raceways in the following locations:
   a. Loading dock.
   b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
   c. Mechanical rooms.
   d. Fire pump room.
4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
6. Damp or Wet Locations: Rigid steel conduit.
7. Raceways for Optical Fiber or Communications Cable: EMT or plenum rated inner duct.
8. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, stainless steel in damp or wet locations.

9. Exposed or underground conduit to sewage ejector pump chamber: PVC coated rigid steel conduit.
10. Exposed or underground conduit to acid neutralization chamber: PVC coated rigid steel conduit.

C. Parking Garage: Apply raceway products as specified below, unless otherwise indicated:

1. Exposed: Rigid hot-dipped galvanized steel with threaded fittings. (EMT conduit shall not be used in any location.)
   a. Acceptable Manufacturers:
      1) Allied Tube & Conduit Corp.
      2) Western Tube & Conduit Corp.
      3) Wheatland Tube Co.

2. Embedded and Underground: 100% pure, polyvinyl chloride (PVC) rigid, Schedule 40
3. with cemented couplings in accordance with NEMA TC-6.
4. At building expansion joints provide at exposed conduit runs only:
5. Outlet, device, pull and junction boxes, conduit bodies and fittings shall be sized per NEC. All conduit connections shall be threaded.
6. Surface boxes and covers: (Aluminum boxes are not acceptable)
   a. Weatherproof hot-dip galvanized cast metal or malleable iron with threaded fittings.
   b. Weatherproof zinc electroplated cast metal or malleable iron with threaded fittings.

7. Boxes for other areas and uses: Gasketed screw cover boxes, 14 or 12 gage, G-90 grade galvanized bodies, 12 or 10 gage G-90 grade galvanized steel covers, NEMA 3R GSC with threaded hubs.
8. Boxes embedded in walls: Concrete type.

D. Minimum Raceway Size: 3/4” trade size.

E. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.

3.2 INSTALLATION

A. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.

B. Keep raceways at least 6 inches (150 mm) away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.

C. Complete raceway installation before starting conductor installation.

D. Support raceways as specified in Division 26 Section "Hangers and Supports for Electrical Systems."

E. Arrange stub-ups so curved portions of bends are not visible above the finished slab.

F. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.

G. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.

H. Unless indicated otherwise, conceal conduit under floor slabs and within finished walls, ceilings, and floors. Keep conduit minimum 6 inches away from parallel runs of flues and steam or hot water pipes. Install conduit parallel with or at right angles to ceilings, walls, and structural members where located above accessible ceilings and where conduit will be visible after completion of project. Run conduits under floor slab as if exposed.

I. Restrictions Applicable to EMT

1. Do not install underground.
2. Do not encase in concrete, mortar, grout, or other cementitious materials.
3. Do not use in areas subject to severe physical damage including but not limited to equipment rooms where moving or replacing equipment could physically damage the EMT.
4. Do not use in hazardous areas.
5. Do not use outdoors.
6. Do not use in fire pump rooms.

J. Restrictions Applicable to Nonmetallic Conduit

1. PVC Schedule 40 and PVC Schedule 80
   a. Do not use in areas where subject to severe physical damage, including but not limited to, mechanical equipment rooms, electrical equipment rooms, and other such areas.
   b. Do not use in hazardous (classified) areas.
   c. Do not use in fire pump rooms.
   d. Do not use in penetrating fire-rated walls or partitions, or fire-rated floors.
   e. Do not use above grade.
   f. Convert nonmetallic conduit, to rigid steel conduit before rising through floor slab.

K. Restrictions Applicable to Flexible Conduit

1. Use only as specified in paragraph FLEXIBLE CONNECTIONS. Do not use when the enclosed conductors must be shielded from the effects of High-altitude Electromagnetic Pulse (HEMP).

L. Service Entrance Conduit, Underground

1. PVC, Type-EPC 40, galvanized rigid steel.
2. Convert nonmetallic conduit to rigid steel conduit before rising through floor slab.

M. Underground Conduit Other Than Service Entrance

1. Tape Wrapped rigid steel; PVC, Type EPC-40. Convert nonmetallic conduit to rigid steel conduit before rising through floor slab. Ten mil tape shall be 1/2 lapped and extend a minimum of 6 inches above floor.
2. Convert nonmetallic conduit to rigid steel conduit before rising through floor slab.

N. Conduit Installed Under Floor Slabs

1. Conduit run under floor slab shall be located a minimum of 12 inches below the vapor barrier. Seal around conduits at penetrations thru vapor barrier.

2. The Electrical Subcontractor will provide and pay for excavations and backfill for under grade slab conduit runs and coordinate the same with other utilities.
3. All structural fill/bedding material must be installed in accordance with the earthwork specifications, including compaction.

O. Conduit Through Floor Slabs

1. Where conduits rise through floor slabs, curved portion of bends shall not be visible above finished slab.
2. Convert nonmetallic conduit to rigid steel conduit before rising through floor slab.

P. Conduit Installed in Concrete Floor Slabs

1. Rigid steel; PVC, Type EPC-40. Locate so as not to adversely affect structural strength of slabs. Install conduit within middle one-third of concrete slab. Do not stack conduits.
2. Space conduits horizontally not closer than three diameters, except at cabinet locations. Curved portions of bends shall not be visible above finish slab.
3. Increase slab thickness as necessary to provide minimum one inch cover over conduit.
4. Where embedded conduits cross building and/or expansion joints, provide suitable watertight expansion/deflection fittings and bonding jumpers. Expansion/deflection fittings shall allow horizontal and vertical movement of raceway.
5. Conduit larger than one inch trade size shall be parallel with or at right angles to main reinforcement; when at right angles to reinforcement, conduit shall be close to one of supports of slab.
6. Where nonmetallic conduit is used, raceway shall be converted to rigid steel before rising above floor, unless specifically indicated.

Q. Stub-Ups

1. Provide conduits stubbed up through concrete floor for connection to free-standing equipment with adjustable top or coupling threaded inside for plugs, set flush with finished floor. Extend conductors to equipment in rigid steel conduit, except that flexible metal conduit may be used 6 inches above floor. Where no equipment connections are made, install screwdriver-operated threaded flush plugs in conduit end.
2. Convert nonmetallic conduit to rigid steel conduit before rising through floor slab.

R. Conduit Support

1. Support conduit by pipe straps, wall brackets, hangers, or ceiling trapeze. Fasten by wood screws to wood; by toggle bolts on hollow masonry units; by concrete inserts or expansion bolts on concrete or brick; and by machine screws, welded threaded studs, or spring-tension clamps on steel work.
2. Threaded C-clamps may be used on rigid steel conduit only. Do not weld conduits or pipe straps to steel structures. Load applied to fasteners shall not exceed one-fourth proof test load.
3. Fasteners attached to concrete ceiling shall be vibration resistant and shock-resistant.
4. Holes cut to depth of more than 1 1/2 inches in reinforced concrete beams or to depth of more than 3/4 inch in concrete joints shall not cut main reinforcing bars. Fill unused holes.
5. In partitions of light steel construction, use sheet metal screws. In suspended-ceiling construction, run conduit above ceiling. Do not support conduit by ceiling support system.
6. Conduit and box systems shall be supported independently of both (a) tie wires supporting ceiling grid system, and (b) ceiling grid system into which ceiling panels are

placed. Supporting means shall not be shared between electrical raceways and mechanical piping or ducts.

7. Installation shall be coordinated with above-ceiling mechanical systems to assure maximum accessibility to all systems.
8. Spring-steel fasteners may be used for lighting branch circuit conduit supports in suspended ceilings in dry locations. Support exposed risers in wire shafts of multistory buildings by U-clamp hangers at each floor level and at 10 foot maximum intervals.
9. Where conduit crosses building expansion joints, provide suitable watertight expansion fitting that maintains conduit electrical continuity by bonding jumpers or other means.
10. For conduits greater than 2 1/2 inches inside diameter, provide supports to resist forces of 0.5 times the equipment weight in any direction and 1.5 times the equipment weight in the downward direction.

S. Directional Changes in Conduit Runs

1. Make changes in direction of runs with symmetrical bends or cast-metal fittings. Make field-made bends and offsets with hickey or conduit-bending machine. Do not install crushed or deformed conduits. Avoid trapped conduits. Prevent plaster, dirt, or trash from lodging in conduits, boxes, fittings, and equipment during construction. Free clogged conduits of obstructions.

T. Locknuts and Bushings

1. Fasten conduits to sheet metal boxes and cabinets with two locknuts where required by NFPA 70, where insulated bushings are used, and where bushings cannot be brought into firm contact with the box; otherwise, use at least minimum single locknut and bushing. Locknuts shall have sharp edges for digging into wall of metal enclosures. Install bushings on ends of conduits, and provide insulating type where required by NFPA 70.

U. Flexible Connections

1. Provide flexible steel conduit between 3 and 6 feet in length for recessed and semi-recessed lighting fixtures; for equipment subject to vibration, noise transmission, or movement; and for motors. Install flexible conduit to allow 20 percent slack. Minimum flexible steel conduit size shall be 1/2 inch diameter. Provide liquidtight flexible conduit in wet and damp locations and in fire pump rooms for equipment subject to vibration, noise transmission, movement or motors. Provide separate ground conductor across flexible connections.

V. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.

W. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb (90-kg) tensile strength. Leave at least 12 inches (300 mm) of slack at each end of pull wire.

X. Raceways for Optical Fiber and Communications Cable: Install as follows:

1. 3/4-Inch (19-mm) Trade Size and Smaller: Install raceways in maximum lengths of 50 feet (15 m).
2. 1-Inch (25-mm) Trade Size and Larger: Install raceways in maximum lengths of 75 feet (23 m).
3. Install with a maximum of two 90-degree bends or equivalent for each length of raceway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes

or terminations at distribution frames or cabinets where necessary to comply with these requirements.

Y. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where otherwise required by NFPA 70.

Z. Expansion-Joint Fittings for RNC: Install in each run of aboveground conduit that is located where environmental temperature change may exceed 30 deg F (17 deg C), and that has straight-run length that exceeds 25 feet (7.6 m).

1. Install expansion-joint fittings for each of the following locations, and provide type and quantity of fittings that accommodate temperature change listed for location:
   a. Outdoor Locations Not Exposed to Direct Sunlight: 125 deg F (70 deg C) change.
   b. Outdoor Locations Exposed to Direct Sunlight: 155 deg F (86 deg C) temperature change.
   c. Indoor Spaces: Connected with the Outdoors without Physical Separation: 125 deg F (70 deg C) temperature change.
   d. Attics: 135 deg F (75 deg C) temperature change.

2. Install fitting(s) that provide expansion and contraction for at least 0.00041 inch per foot of length of straight run per deg F (0.06 mm per meter of length of straight run per deg C) of temperature change.
3. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at the time of installation.

AA. Flexible Conduit Connections: Use maximum of 72 inches (1830 mm) of flexible conduit for recessed and semi recessed lighting fixtures,]equipment subject to vibration, noise transmission, or movement; and for transformers and motors.

1. Use LFMC in damp or wet locations subject to severe physical damage.
2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.

BB. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall.

CC. Set metal floor boxes level and flush with finished floor surface.

DD. Set nonmetallic floor boxes level. Trim after installation to fit flush with finished floor surface.

3.3 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Division 31 Section "Earth Moving" for pipe less than 6 inches (150 mm) in nominal diameter.

2. Install backfill as specified in Division 31 Section "Earth Moving."
3. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches (300 mm) of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Division 31 Section "Earth Moving."
4. Install manufactured duct elbows for stub-ups at poles and equipment and at building entrances through the floor, unless otherwise indicated. Encase elbows for stub-up ducts throughout the length of the elbow.
5. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.
    a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete.
    b. For stub-ups at equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.

6. Warning Planks: Bury warning planks approximately 12 inches (300 mm) above direct-buried conduits, placing them 24 inches (600 mm) O.C. Align planks along the width and along the centerline of conduit.

End of Section

Section 26 05 48

VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. Section includes:

1. Isolation pads.
2. Spring isolators.
3. Restrained spring isolators.
4. Channel support systems.
5. Restraint cables.
6. Hanger rod stiffeners.
7. Anchorage bushings and washers.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic-Restraint Loading:

1. Site Class as Defined in the State Building Code.
2. Assigned Seismic Use Group or Building Category as Defined in the State Building Code.

1.5 SUBMITTALS

A. Product Data: For the following.

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.

a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
b. Annotate to indicate application of each product submitted and compliance with requirements.

3. Restrained-Isolation Devices: Include ratings for horizontal, vertical, and combined loads.

B. Delegated-Design Submittal: For vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators and seismic restraints.
a. Coordinate design calculations with wind-load calculations required for equipment mounted outdoors. Comply with requirements in other Division 26 Sections for equipment mounted outdoors.

2. Indicate materials and dimensions and identify hardware, including attachment and anchorage devices.
3. Field-fabricated supports.
4. Seismic-Restraint Details:
a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
c. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

C. Welding certificates.

D. Field quality-control reports.

1.6 QUALITY ASSURANCE

A. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.

B. Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."

C. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.

D. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

A. Approved Manufacturers

1. Ace Mountings Co., Inc.
2. Amber/Booth Company, Inc.
3. California Dynamics Corporation.
4. Or approved equal.

B. Pads: Arrange in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.

1. Resilient Material: Oil- and water-resistant neoprene.

C. Spring Isolators: Freestanding, laterally stable, open-spring isolators.

1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
5. Baseplates: Factory drilled for bolting to structure and bonded to 1/4-inch- (6-mm-) thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to 500 psig (3447 kPa).
6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.

D. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
2. Restraint: Seismic or limit-stop as required for equipment and authorities having jurisdiction.
3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.2 SEISMIC-RESTRAINT DEVICES

A. Approved Manufacturers

1. Amber/Booth Company, Inc.
2. California Dynamics Corporation.
3. Cooper B-Line, Inc.; a division of Cooper Industries.
4. Or approved equal.

B. General Requirements for Restraint Components: Rated strengths, features, and application requirements shall be as defined in reports by an agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

C. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.

D. Restraint Cables: ASTM A 492 stainless-steel cables with end connections made of steel assemblies with thimbles, brackets, swivels, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.

E. Hanger Rod Stiffener: [Steel tube or steel slotted-support-system sleeve with internally bolted connections] [Reinforcing steel angle clamped] to hanger rod. Do not weld stiffeners to rods.

F. Bushings for Floor-Mounted Equipment Anchor: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchors and studs.

G. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices.

H. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.

I. Mechanical Anchor: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchors with strength required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.

J. Adhesive Anchor: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

PART 3 - EXECUTION

3.1 APPLICATIONS

A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.

B. Hanger Rod Stiffeners: Install hanger rod stiffeners where indicated or scheduled on Drawings to receive them and where required to prevent buckling of hanger rods due to seismic forces.

C. Strength of Support and Seismic-Restraint Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.2 SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Equipment and Hanger Restraints:

1. Install restrained isolators on electrical equipment.
2. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds 0.125 inch (3.2 mm).
3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

B. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

C. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

D. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.3 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

A. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where they terminate with connection to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

3.4 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
2. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
3. Test to 90 percent of rated proof load of device.
4. Measure isolator restraint clearance.
5. Measure isolator deflection.
6. Verify snubber minimum clearances.
7. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.

B. Remove and replace malfunctioning units and retest as specified above.

C. Prepare test and inspection reports.

3.5 ADJUSTING

A. Adjust isolators after isolated equipment is at operating weight.

B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.

C. Adjust active height of spring isolators.

D. Adjust restraints to permit free movement of equipment within normal mode of operation.

End of Section

Section 26 05 53

IDENTIFICATION FOR ELECTRICAL SYSTEMS

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. This Section includes the following:

1. Identification for conductors and communication and control cable.
2. Warning labels and signs.
3. Equipment identification labels.

1.4 SUBMITTALS

A. Product Data: For each electrical identification product indicated.

1.5 QUALITY ASSURANCE

A. Comply with ANSI A13.1.

1.6 COORDINATION

A. Coordinate identification names, abbreviations, colors, and other features with requirements in the Contract Documents, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual, and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.

PART 2 - PRODUCTS

2.1 MANUFACTURERS:

A. Approved manufacturers

1. T&B.
2. 3M
3. EMED Co.
4. Or approved equal.

2.2 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. Warning Signs: Provide warning signs where there is hazardous exposure associated with access to or operation of electrical facilities. Provide text of sufficient clarity and lettering of sufficient size to convey adequate information at each location; mount permanently in an appropriate and effective location. Comply with recognized industry standards for color and design.

C. Operational Tags: Where needed for proper and adequate information on operation and maintenance of electrical systems, provide tags of plasticized card stock, preprinted.

D. Self-Adhesive Warning Labels: Factory printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment, unless otherwise indicated.

E. Baked-Enamel Warning Signs: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application. 1/4-inch (6.4-mm) grommets in corners for mounting. Nominal size, 7 by 10 inches (180 by 250 mm).

F. Metal-Backed, Butyrate Warning Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch (1-mm) galvanized-steel backing; and with colors, legend, and size required for application. 1/4-inch (6.4-mm) grommets in corners for mounting. Nominal size, 10 by 14 inches (250 by 360 mm).

G. Fasteners for Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

H. Warning label and sign shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES (915 mm)."

2.3 ELECTRICAL SYSTEM IDENTIFICATION

A. Identification of Equipment:

1. All pieces of major electrical equipment shall have a manufacturer's label identifying the manufacturer's address, equipment model and serial numbers, equipment size, and other pertinent data. Care shall be taken not to obliterate this nameplate in any way.
2. The Contractor shall make it possible for the personnel operating and maintaining the equipment and systems in this project to readily identify the various pieces of equipment, junction boxes, etc., by marking them. All items of equipment, pull boxes, junction boxes, etc., shall be clearly marked using engraved nameplates as hereinafter specified. The item of equipment shall indicate the same number as shown on the Drawings, where applicable.
3. White background and black letters equipment nameplates shall be three ply laminated plastic, a minimum of 3/32" thick, black background, white letters for normal power, red background, white letters for emergency power, and blue-white-blue for UPS power. Letters shall be similar to Roman Gothic of a size that is legible (1/2" minimum for main nameplates and 3/8" minimum for branch device nameplates) and appropriate to the application. Attachment of nameplates shall be by stainless steel screws. Rivets or adhesives are not acceptable.
    a. Electrical equipment to be identified includes: All switchgear, switchboards, unit substations, distribution panels, transformers, motor control centers, panelboards, automatic transfer switches, busway plugs, disconnect switches, motor controller/starters, lighting control panels, pull boxes, junction boxes, and similar equipment.
    b. Nameplates on switchgear, switchboards, unit substations, automatic transfer switches, transformers, distribution panels, motor control centers, disconnect switches, motor controller/starters, variable frequency drives and panelboards shall give voltage and current characteristics and the source feeding the panel. Current characteristics shall indicate the size of the overcurrent devices serving the equipment and not the equipment current rating.
        1) Provide panel and circuit designation on disconnect switches, motor controllers/starters, variable frequency drives, etc.

        Example:

        PANEL PP2
        120/208V, 3PH, 4 W, 225 A
        Fed from DPA-3
        Room 1.102
    c. Individual overcurrent devices and pilot lights in switchgear, switchboards, unit substations, distribution panels, motor control centers, and similar equipment shall have nameplates showing the load served and its location, where remote. Nameplates on motor starters shall indicate variable speed, time delay operation, etc., where applicable.
    d. Blank nameplates shall be mounted on each spare or bussed space in motor control centers, and on each spare or space in distribution panels.
    e. Branch circuit panelboards shall have neatly typed circuit directories behind clear plastic. Identify circuits by room numbers. Room numbers shall be those finally selected by the Owner; not necessarily those given on contract Drawings. Spares and spaces shall be indicated with erasable pencil; not typed. Circuit numbers shall be provided in the directory and at each circuit breaker.

B. Conduit Systems: Provide adequate marking of major conduit which is exposed or concealed in accessible spaces, to distinguish each run as either a normal power, emergency power, fire alarm, control wiring or voice/data conduit. Except as otherwise indicated, use white banding with black lettering except that emergency power orange and white, fire alarm conduit markers shall use red banding. Provide self-adhesive or snap-on type plastic markers. Indicate voltage ratings of conductors exceeding 250 volts. Locate markers at ends of conduit runs, near

switches and other control devices, near items of equipment served by the conductors, at points where conduit passes through walls or floors, or enters non-accessible construction and at spacings of not more than 30' along each run of exposed conduit.

C. Cable Tray Systems: Provide engraved nameplates identifying cable tray systems as to use, on maximum 50' centers on all tray systems and whenever a tray enters a room or concealed accessible location. Nameplate text shall be submitted to the Engineer for review.

D. Underground Cable Identification: Bury a continuous, preprinted, red and silver metallic ribbon cable marker, Brady No. 91600 Series or an approved equal with each underground cable (or group of cables), regardless of whether conductors are in conduit or direct buried. Locate each directly over cables, 12" above cable below finished grade. Ribbons shall be detectable from above grade using a pipe or cable locator.

E. Cable/Conductor Identification: Coordinate a uniform and consistent scheme of color identification of power wiring throughout the building system. Identification shall be by the permanent color of the selected covering. On large conductors, secure identification by means of painted color banding or plastic tape.

1. Color scheme shall be as follows, [or as required to match the existing color coding in the building for 120/240 V systems with high leg provide Orange for phase B]

	208/120 Volt	480/277 Volt	5kV/15kV
Phase A	Black	Brown	Black
Phase B	Red	Purple	Red
Phase C	Blue	Yellow	Blue
Neutral	White	Gray	White
Ground	Green	Green	

2. Wiring for switches shall be same color as phase wire.
3. Colored insulation in sizes up through #4. Conductors #3 and larger may have black insulation, but color coded with 1/2" wide band of colored tape, at accessible locations. Rap conductor minimum 6" width.
4. Feeder cables shall be tagged in pull boxes, wireways, wiring gutters of panels, and at other accessible locations. Tags shall be fireproof, nonconductive material, approved by Architect.
5. Maintain same conductor color from service entrance to last device.

F. Phase Rotation: Phase rotation shall be maintained throughout the project.

1. Phase rotation shall be clockwise or counterclockwise, per serving power company standards, A-B-C, and identified as such left-to-night, top-to-bottom, and front-to-back with color coding as specified above at switchboards, panelboards, substations, transformers, motor control centers, motor starters, and similar locations.
2. Motor phase reversal, if necessary, shall be made at motor controller.

G. Branch Circuit and Control Wiring Tags: All branch circuit and control wiring conductors shall be tagged using self-sticking vinyl cloth or mylar cloth wire markers. Embossed pressure sensitive plastic or metal ribbon markers will not be accepted. Tags shall be installed at all wiring splice, tap and termination points and shall correspond to the designations shown on the control wiring diagrams or panel schedules.

H. Branch Circuit Pull Boxes and Junction Boxes: Branch circuit pull boxes shall be neatly stenciled with a black permanent marker indicating the panel name and branch circuit number.

Boxes on emergency power systems shall be painted orange prior to marking. Boxes on fire alarm power systems shall be painted red prior to marking.

I. Miscellaneous Switch Plates or Device Plates: Adhesive Film Label with Clear Protective Overlay for interior use: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm).

1. Nomenclature shall include the panel and circuit of the outlet or switch, or the indication of the pilot, or the area of control, or equipment served.
2. Switched and non-switched device plates shall be engraved. Engraving shall be 3/16" condensed Gothic and shall be filled with black enamel.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

E. Attach non-adhesive signs and plastic labels with screws and auxiliary hardware appropriate to the location and substrate.

3.2 CLEANING AND PAINTING OF ELECTRICAL WORK

A. Prime, protective and touch-up painting is included in the Work of this Division. Finish painting in equipment spaces, concealed locations, and other locations not exposed to the view of building occupants is included in the work of this Division. Finished painting in areas exposed to the view of building occupants is specified under Division 9.

B. All equipment and materials furnished by the electrical subcontractor shall be delivered to the job with suitable factory protective finish.

C. Electrical switchgear, disconnect switches, contactors, etc., with suitable factory-applied finishes shall not be repainted; except for aesthetic reasons where located in finished areas as directed by the Architect and in a color selected by the Architect. Where factory-applied finishes are damaged in transit, storage or installation, or before final acceptance, they shall be restored to factory-fresh condition by competent refinishers using the spray process.

D. All equipment not finished at the factory shall be given a prime coat and then finish painted with two coats of enamel in a color as directed by the Architect/Engineer. No nameplates on equipment shall be painted, and suitable protection shall be afforded such plates to prevent their being rendered illegible during the painting operations.

E. The surfaces to be finish-painted shall first be prepared as follows:

1. Galvanized and black steel surfaces shall first be painted with one coat of galvanized metal primer.
2. Aluminum surfaces shall first be painted with one coat of zinc chromate primer.

F. All ferrous metal surfaces without a protective finish and not galvanized in exposed and concealed areas including chases, under floor and above ceilings shall be painted with two coats of zinc chromate primer as the construction progresses to protect against deterioration.

G. All junction and pull boxes and covers which are part of raceway systems distributing emergency power shall be painted orange. Where a multiple branch emergency power system is installed, the branch designation (LS, CB or EQ) shall be stenciled on the box cover in minimum one inch (1") high white letters.

H. All junction and pull boxes and covers and terminal cabinets which are part of the raceway/wiring system for emergency alarm wiring shall be painted orange and fire alarm wiring shall be painted red. A system designation (FA) shall be stenciled on the box or cabinet cover in minimum one inch (1") high white letters.

I. All conduit exposed to view shall be finish painted as directed by the Architect.

J. Before painting, all surfaces to be painted shall be suitably prepared. This shall include removing all oil, rust, scale, dirt, and other foreign material. Surfaces shall be made smooth by grinding, filing, brushing, or other approved method. In the painting operations, the primer for metal surfaces shall be of the zinc dust type unless specified otherwise, and where finish painting is specified, it shall be painted using materials and colors selected and approved by the Architect. Refer to Division 9 for additional requirements.

End of Section

Section 26 05 73

OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. This Section includes requirements for computer-based fault-current, overcurrent protective device coordination and arc flash protection studies. Protective devices shall be set based on Engineer’s review of submitted results of the protective device coordination study.

1. Coordination of series–rated devices is not permitted.

1.4 PERFORMANCE REQUIREMENTS

A. Fault Current Study: Prepare computer-based, fault current study to calculate the maximum available short-circuit current in amperes RMS symmetrical at circuit-breaker positions of the electrical power distribution system based on proposed feeder routing.

B. Overcurrent Protective Device Coordination: Prepare computer-based, selective coordination study such that all overcurrent protective devices proposed for inclusion in the Work shall be selected to be selectively coordinated for total selective coordination with the overcurrent protective devices installed on their supply side such that an overcurrent event (overload, short-circuit, or ground-fault) occurring at the lowest level in the system (branch circuit) cannot cause the feeder protective device supplying the branch circuit panelboard to open.

1. Total selective coordination shall be carried through each level of distribution for all branches of emergency power system. Emergency power systems shall include life safety, legally required standby systems, critical operations power systems, and fire pumps.
2. The normal power system and standby power system shall be coordinate to 0.01s.

C. Arc Flash Hazard Analysis: Prepare computer-based, arc-flash study to determine the arc-flash hazard distance and the incident energy to which personnel could be exposed during work on or near electrical equipment.

1.5 DEFINITIONS

A. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

B. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

C. SCCR: Short-circuit current rating.

D. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.6 SUBMITTALS

A. The release of electrical equipment submittals (panelboards, engine generators, switchgear, etc.) is dependent on the receipt of a complete and accurate overcurrent protective device coordination study. The following submittals shall be in digital form:

1. Coordination-study input data, including completed computer program input data sheets. Provide editable electronic media including all files and breaker TCC's.
2. Study and Equipment Evaluation Reports.
3. Coordination-Study Report; signed, dated, and sealed by a qualified professional engineer.
4. Arc-flash study input data, including completed computer program input data sheets.
5. Arc Flash Hazard Analysis Report; signed, dated, and sealed by a qualified professional engineer.

B. Product Data: For computer software program to be used for studies.

C. Qualification Data: For Coordination Study Specialist and Arc-Flash Hazard Analysis Specialist.

D. Product Certificates: For coordination-study and fault-current-study computer software programs, certifying compliance with IEEE 399. For arc-flash hazard analysis software, certifying compliance with IEEE 1584 and NFPA 70E.

E. Maintenance procedures according to requirements in NFPA 70E shall be provided in the equipment manuals.

1.7 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are not acceptable.

B. Qualifications: Comprehensive engineering analysis by qualified Professional Engineer or personnel trained and employed by the equipment manufacturer in required calculation methodology.

1. Analysis to be performed by Professional Engineer or personnel trained, employed, and supervised by a registered Professional Engineer.
2. Registered professional engineer shall be a full-time employee of the electrical equipment manufacturer or a professional engineering firm.
3. Report shall be signed and sealed by a Professional Engineer with current registration.

C. Comply with IEEE 242 for short-circuit currents and coordination time intervals.

D. Comply with IEEE 399 for general study procedures.

E. Comply with IEEE 1584 for performing Arc Flash Hazard Calculations.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers

1. SKM Systems Analysis, Inc.
2. EasyPower, LLC
3. Power Analytics Corporation
4. Or approved equal

2.2 COMPUTER SOFTWARE PROGRAM REQUIREMENTS

A. Comply with IEEE 399 for fault-current and overcurrent protective device coordination studies.

B. Comply with IEEE 1584 and NFPA 70E for arc-flash hazard analysis.

C. Analytical features of fault-current-study computer software program shall include "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate coordination by computer-generated, time-current coordination plots.

2.3 POWER SYSTEM STUDIES

A. The Electrical Trade Contractor shall request information required to complete the power system studies from the Utility Company. This information shall be provided to the manufacturer upon request.

B. The manufacturer shall make all necessary modifications to the circuit breaker types for a fully coordinate electrical system to comply with the specifications.

C. Short Circuits Studies, Protective Device Evaluation Studies, and Protective Device Coordination Studies shall be provided by the Manufacturer. The studies shall be submitted to the Engineer prior to receiving final approval of the distribution equipment shop drawings and/or prior to release of equipment for manufacture. If formal completion of the studies may cause delay in equipment manufacture, approval may be obtained for a preliminary submittal of sufficient study data to ensure that the selection of device ratings and characteristics will be satisfactory.

2.4 POWER SYSTEM DATA

A. The Design System Analyst performing the short-circuit, protective device coordination study, and arc flash hazard analysis shall furnish the Contractor with a list of required data immediately after award of the contract. Contractor shall expedite collection of the data to ensure completion of the study and analysis as required.

B. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.

C. Source combination shall include present and future motors and generators indicated in the documents.

D. If applicable, include fault contribution of existing motors in the study and analysis.

E. Gather and tabulate the following input data to support coordination study:

1. Product Data for overcurrent protective devices specified in other Division 26 Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Impedance of utility service entrance.
3. Electrical Distribution System Diagram: In hard-copy and electronic-copy formats, showing the following:
   a. Circuit breakers and fuses ratings and types.
   b. Relays and associated power and current transformer ratings and ratios.
   c. Transformer kilovolt amperes, primary and secondary voltages, connection type, impedance, X/R ratios, taps measured in per cent, and phase shift.
   d. Generator short-circuit current contribution data, including short-circuit reactance, rated kilovolt amperes, size, rated voltage, and X/R ratio.
   e. Cables: Indicate conduit material, sizes of conductors, conductor material, insulation, and length.
   f. Busway ampacity, impedance, lengths, and conductor material.
   g. Motor horsepower and code letter designation according to NEMA MG 1.
   h. Low-voltage cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).
   i. Medium-voltage cable sizes, lengths, conductor material, and cable construction and metallic shield performance parameters.

4. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:
   a. Special load considerations, including starting inrush currents and frequent starting and stopping.
   b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.

c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
d. Generator thermal-damage curve.
e. Ratings, types, and settings of utility company's overcurrent protective devices.
f. Special overcurrent protective device settings or types stipulated by utility company.
g. Time-current-characteristic curves of devices.
h. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
j. Panelboards, switchboards, motor-control center ampacity, and interrupting rating in amperes rms symmetrical.

2.5 SHORT-CIRCUIT STUDY REPORT CONTENT

A. Executive Summary

B. Study descriptions, purpose, basis and scope of the study.

C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings.
2. Cable size and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center and panelboard designations.

D. Study Input Data: As described in "Power System Data" Article.

E. Short-Circuit Study Output:

1. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:
   a. Voltage.
   b. Calculated symmetrical fault-current magnitude and angle.
   c. Fault-point X/R ratio.
   d. No AC Decrement (NACD) ratio.
   e. Equivalent impedance.
   f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
   g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

F. Incident Energy and Flash Protection Boundary:

1. Calculations:
   a. Arcing fault magnitude.
   b. Protective device clearing time.
   c. Duration of arc.
   d. Arc-flash boundary.
   e. Working distance.
   f. Incident energy.

g. Hazard risk category.
h. Recommendations for arc-flash energy reduction.

2. Circuit breakers rated 1200A and higher shall be provided with an Arc flash Reduction Maintenance System for accelerated instantaneous trip to reduce arc flash. The setting shall be determined by the arc flash study and set in the field by the manufacturer's representative.
   a. The pickup setting is chosen using the following steps:
      1) Calculate the arcing fault current that could flow through the circuit breaker associated with the Arc flash Reduction Maintenance System. Formulas from IEEE STD 1584TM-2002 are used to calculate the arcing current.
      2) Determine the total transient load current that can flow to loads fed by the circuit breaker equipped with the Arc flash Reduction Maintenance System. These can include motor inrush and transformer inrush.
      3) Choose a pickup setting for the Arc flash Reduction Maintenance System that is:
         a) Below 75% of calculated arcing current.
         b) Above the total transient load current.

G. Fault study input data, case descriptions, and fault-current calculations including a definition of terms and guide for interpretation of the computer printout.

H. Equipment specific Arc Flash Warning Labels.

I. Recommendations for system improvements, where needed.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance.

1. Proceed with coordination study and arc-flash study only after relevant equipment submittals have been assembled, but prior to their submission to the Architect.
2. Coordination study shall accompany submission of relevant equipment submittals.

3.2 FAULT-CURRENT STUDY

A. A short-circuit current ratings indicated in the Contract Documents are based on Fault-Current study prepared by the Engineer during design and are based on available information and anticipated feeder lengths. Calculate the maximum available short-circuit current in amperes rms symmetrical at circuit-breaker positions of the electrical power distribution system based on proposed feeder routing. The calculation shall be for a current immediately after initiation and for a three-phase bolted short circuit at each of the following:

1. Electric Utility's supply termination point.
2. Switchgear and switchboard bus.
3. Motor-control center.
4. Distribution panelboard.
5. Branch circuit panelboard.
6. Standby Generators and Transfer Switches.

7. Enclosed Fused Switch.
8. Enclosed Circuit Breaker.

B. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Include studies of system-switching configurations and alternate operations that could result in maximum fault conditions.

C. Calculate momentary and interrupting duties on the basis of maximum available fault current.

D. Calculate short-circuit currents according to IEEE 551.

E. Calculations to verify interrupting ratings of overcurrent protective devices shall comply with IEEE 241 and IEEE 242.

1. Transformers, as appropriate for transformers included in the Work:
   a. ANSI C57.12.10.
   b. ANSI C57.12.22.
   c. ANSI C57.12.40.
   d. IEEE C57.12.00.
   e. IEEE C57.96.

2. Medium-Voltage Circuit Breakers: IEEE C37.010.
3. Low-Voltage Circuit Breakers: IEEE 1015 and IEEE C37.20.1.
4. Low-Voltage Fuses: IEEE C37.46.

F. Study Report:

1. Show calculated X/R ratios and equipment interrupting rating (1/2-cycle) fault currents on electrical distribution system diagram.

G. Equipment Evaluation Report:

1. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
2. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.
3. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
4. Notify Engineer, in writing, of any existing circuit protective devices improperly rated for the calculated available fault current.

3.3 COORDINATION STUDY

A. Coordination (Selective): Localization of an overcurrent condition to restrict outages to the circuit or equipment affected, accomplished by the selection and installation of overcurrent protective devices and their ratings or settings for the full range of available overcurrents, from overload to the maximum available fault current, and for the full range of overcurrent protective device opening times associated with those overcurrents.

1. Emergency system (Life Safety) overcurrent devices shall be fully selectively coordinated with all supply side overcurrent protective devices (emergency and normal).

B. Perform coordination study using approved computer software program. Prepare a written report using results of fault-current study. Comply with IEEE 399.

1. Calculate the maximum and minimum 1/2-cycle short-circuit currents.
2. Calculate the maximum and minimum ground-fault currents.

C. Comply with IEEE 241 and IEEE 242 recommendations for fault currents and time intervals.

D. The studies shall include all portions of the electrical distribution system from the normal power source and emergency/standby power sources down to and including the 120/208V distribution system. Normal/emergency/standby system connections and those which result in maximum fault conditions shall be adequately covered in the study.

E. All emergency system overcurrent devices shall be selectively coordinated with the overcurrent devices installed on their supply side per Section 700.27 of the National Electrical Code. The generator circuit breakers shall be of the same manufacturer as the switchboard. Provide a letter from the manufacturer stating that the overcurrent devices have been selectively coordinated.

F. Perform coordination study using approved computer software program. Prepare a written report using results of fault-current study. Comply with IEEE 399.

1. Calculate the maximum and minimum 1/2-cycle short-circuit currents.
2. Calculate the maximum and minimum ground-fault currents.

G. Comply with IEEE 241 and IEEE 242 recommendations for fault currents and time intervals.

H. Transformer Primary Overcurrent Protective Devices:

1. Device shall not operate in response to the following:
   a. Inrush current when first energized.
   b. Self-cooled, full-load current or forced-air-cooled, full-load current, whichever is specified for that transformer.
   c. Permissible transformer overloads according to IEEE C57.96 if required by unusual loading or emergency conditions.

2. Device settings shall protect transformers according to IEEE C57.12.00, for fault currents.

I. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and conductor melting curves in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

J. Coordination-Study Report: Prepare a written report indicating the following results of coordination study:

1. Tabular Format of Settings Selected for Overcurrent Protective Devices:
   a. Device tag.
   b. Relay-current transformer ratios; and tap, time-dial, and instantaneous-pickup values.
   c. Circuit-breaker sensor rating; and long-time, short-time, and instantaneous settings.

d. Fuse-current rating and type.
e. Ground-fault relay-pickup and time-delay settings.

2. Coordination Curves: Prepared to determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:
   a. Device tag.
   b. Voltage and current ratio for curves.
   c. Three-phase and single-phase damage points for each transformer.
   d. No damage, melting, and clearing curves for fuses.
   e. Cable damage curves.
   f. Transformer inrush points.
   g. Maximum fault-current cutoff point.
   h. Motor starting characteristics, damage points and overload relay.
   i. Thermal damage curve for motors larger than 100 HP.
   j. Generator short-circuit decrement curve and damage point, and thermal damage curve.

K. Completed data sheets for setting of overcurrent protective devices.

L. Complete Schedule of breaker settings to summarize information contained on data sheets. Sample schedule has been included at the end of this section for preferred format.

3.4 ARC FLASH HAZARD ANALYSIS

A. Comply with IEEE 1584 for arc flash hazard analysis.

B. Comply with NFPA 70E and its Annex D for hazard analysis study.

C. The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system where work could be performed on energized parts including, but not limited to, the following:

1. Disconnect switches.
2. Electrical substations.
3. Electrical switchgear and switchboards.
4. Emergency system boxes and enclosures.
5. Enclosed circuit breakers.
6. Meter Sockets and assemblies.
7. Motor starter.
8. Motor-control centers.
9. Panelboards.
10. Power transfer equipment. (ATS)
11. Transformers.
12. Uninterruptible power supply equipment.

D. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit and coordination study model. Ground overcurrent protection relays should not be taken into consideration when determining the clearing time when performing incident energy calculations.

E. Calculate the arc-flash protection boundary and the corresponding incident energy calculations for multiple system scenarios to be compared and the greatest incident energy to be uniquely reported for each equipment location. Calculations to be performed to represent the maximum and minimum contributions of fault current magnitude for all normal and emergency operating conditions.

1. The minimum calculation will assume that the utility contribution is at a minimum and will assume a minimum motor contribution (all motors off).
2. The maximum calculation will assume a maximum contribution from the utility and will assume the maximum amount of motors to be operating. Calculations shall take into consideration the parallel operation of synchronous generators with the electric utility, where applicable.

F. Incident energy calculations shall consider the accumulation of energy over time when performing arc flash calculations on buses with multiple sources. Iterative calculations must take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators to be decremented as follows:

1. Fault contribution from induction motors should not be considered beyond 3-5 cycles.
2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible.

G. For each equipment location with a separately enclosed main device, calculations for incident energy and flash protection boundary shall include both the line and load side of the main breaker.

1. When performing incident energy calculations on the line side of a main breaker, the line side and load side contributions must be included in the fault calculation.

H. Mis-coordination should be checked amongst all devices within the branch containing the immediate protective device to compute the incident energy for the corresponding location.

I. Arc Flash calculations shall be based on actual overcurrent protective device clearing time. Maximum clearing time will be capped at 2 seconds based on IEEE 1584 section B.1.2. Where it is not physically possible to move outside of the flash protection boundary in less than 2 seconds during an arc flash even, a maximum clearing time based on the specific location shall be utilized.

J. Complete Arc Flash report to be used for the preparation of Arc Flash Warning labels for electrical equipment. Refer to Division 26 Section “Identification for Electrical Systems” for requirements of Arc Flash Study and labels.

3.5 CORRECT DEFICIENCIES, RE-CALCULATE AND REPORT

A. After Engineer’s initial review, correct unsatisfactory conditions and recalculate to demonstrate compliance; resubmit overcurrent protective devices as required to bring system into compliance.

B. Revise and Resubmit report multiple times as necessary to demonstrate compliance with requirements.

3.6 APPLICATION OF WARNING LABELS

A. Install arc-flash warning labels as specified in Division 26 Section “Identification for Electrical Systems”. Install labels under the direct supervision and control of the Arc-Flash Hazard Study Specialist.

3.7 ARC-FLASH WARNING LABELS

A. Produce a 3.5-by-5-inch (76-by-127-mm) thermal transfer label of high-adhesion polyester for each work location included in the analysis.

B. The label shall have an orange header with the wording, "WARNING, ARC-FLASH HAZARD," and shall include the following information taken directly from the arc-flash hazard analysis:

1. Flash Hazard Boundary.
2. Short Circuit Current Available and date the calculation was performed.
3. Shock Hazard when Cover is Removed.
4. Limited Approach Boundary.
5. Restricted Approach Boundary.
6. Prohibited Approach Boundary.
7. PPE Requirements, including the following:
   a. Hazard Risk Category
   b. Required Minimum Arc Rating of PPE in cal/cm^2
   c. Clothing Description
8. Engineering report number, revision number, and issue date.

C. Labels shall be machine printed, with no field-applied markings.

End of Section

Section 26 09 13

ELECTRICAL POWER MONITORING AND CONTROL

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. It is the intent of these specifications that this Subcontractor, Manufacturer and/or its Authorized System Integrator expeditiously furnishes and installs a system complete in every respect and ready to operate. All miscellaneous items and accessories required for such installation, whether or not each such item or accessory as shown on the plans or mentioned in these specifications, shall be furnished and installed.

B. Application software for personal computer workstations shall be provided as described in this specification.

C. All products shall not violate any U. S. patents.

1.4 REFERENCES

A. The system shall comply with the applicable portions of NEMA standards. In addition, the control unit shall comply with FCC Emission Standards specified in Part 15, Sub-part J for Class A application.

1.5 SUBMITTALS

A. Drawings: Drawings shall show all field monitoring devices, key networking components, and cabling required to complete the system. Drawings shall identify device room location and recommended installation notations. Specific locations and mounting details are subject to the discretion and responsibilities of the installing Subcontractor.

B. Product Data: Provide catalog sheets to indicate physical data and electrical performance, electrical characteristics, and connection requirements of each device supplied under the scope of work.

1.6 QUALITY ASSURANCE

A. Manufacturer Requirements

1. Provide factory-direct technical support hotline.
2. Components included within the power equipment lineups shall be factory installed, wired and tested prior to shipment to the job site.

1.7 DELIVERY, STORAGE & HANDLING

A. Ordering: Comply with manufacturer's ordering instructions and lead-time requirements to avoid construction delays.

B. Delivery

1. Deliver materials in manufacturer's original, unopened, undamaged packages with intact identification labels.
2. Deliver to other trades in a timely manner.

C. Storage and Protection: Store materials away from exposure to harmful weather conditions and at temperature and humidity conditions recommended by manufacturer.

1.8 PROJECT CONDITIONS

A. Do not install equipment until the following conditions can be maintained in spaces to receive equipment:

1. Ambient temperature: 0° to 50° C (32° to 122° F).
2. Relative humidity: Maximum 90 percent, non-condensing.
3. Must be protected from dust during installation.

1.9 MAINTENANCE

A. Enable the end user to order new equipment for system expansion, replacements, and spare parts.

B. Make new replacement parts available.

C. Provide factory-direct technical support hotline.

D. Offer renewable annual service contracts, to include parts, factory labor, and annual training visits.

1.10 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 PRODUCTS

2.1 METER TECHNOLOGY

A. Approved Manufacturers

1. Eaton.
2. ABB.
3. Schneider Electric.
4. Or approved equal.

2.2 BASIS OF DESIGN

A. The system specified is based upon Eaton Power Xpert Multi-Point meter (MPM) and represents the performance standard upon which any equivalent solution shall be based.

2.3 METER

A. Furnish and install microprocessor-based metering equipment where shown on the one-line distribution drawings.

1. Include metering point (up to 60-1 pole, 30-2 pole, 20-3 pole or a combination of 1 pole, 2 pole and 3 pole points for all circuit breakers in the panelboard/switchboard including spares)

B. Panelboard/Switchboard shall be equipped with integral multi-point metering system for metering of all loads fed from the assembly. Manufacturer shall:

1. Install MPM in Panelboard or Switchboard at the factory
2. Pre-wire current sensors and interface modules to MPM.
3. Pre-wire metering voltages and control power connections.
4. Install color HMI at the main switchboard.

2.4 MPM METERING REQUIREMENTS

A. ANSI C12.20 0.5 accuracy class for sub-metering of loads with 125A, 250A and 400 A solid core current sensors with voltage clamping circuits.

B. The MPM metering modules shall meet ANSI C12.20 0.5 accuracy class.

C. MPM shall have a means of supporting ANSI C57.13 5A revenue metering accuracy current transformers with the use of an interface module.

D. Metering system shall be modular in construction with capacity for up to 60 current channels configurable for 20 three phase, 30 two pole or 60 one pole loads or combination thereof.

E. The MPM design shall permit the use of; solid core 100mA sensors, split core 333mV sensors and 5A current transformers on the same MPM.

F. MPM shall support up to 80 channels of pulse metering of other utilities such as Water, Gas, Steam and chilled water.

G. Support for optional outputs to be used for alarm indication.

H. Load Profile intervals shall be configurable as 1, 5, 10, 15, 30 or 60 minutes or controllable from a Demand Synch input.

I. Demand Interval shall be configurable as Fixed 1, 5, 10, 15, 30 or 60 minutes or Sliding with Sub-intervals of 1, 5, 10, 15 or 30 minutes.

J. Interval-by-interval data storage of demand readings shall be programmable from 1-60 minutes.

K. Sufficient memory for a minimum of 2 years of 15-minute interval data

2.5 MPM CONFIGURATION

A. MPM shall include a configuration port compatible with a temporary laptop connection such as a USB interface.

B. The MPM shall be field configurable for combinations of 1, 2 or 3 pole sub-meters with the use of intuitive graphical configuration software.

2.6 COMMUNICATIONS CAPABILITIES

A. Provide two RS-485 MODBUS communications ports to facilitate simultaneous communications to a local HMI display and to a communications gateway.

B. Provide Ethernet communications including Modbus TCP, BACnet/IP, HTTPS, SFTP, SNMP, SMTP and NTP.

1. Configure all MPM for access through the facility's local area network.

2.7 WEB ENABLED CAPABILITIES

A. Provide embedded configurable WEB server. Web server shall support individual operator usernames and passwords.

B. Web pages shall support HTTPS to protect usernames, passwords and metering data from being transmitted in the clear on communications packets.

C. Energy and Power comparisons between user selectable time periods.

D. 2 years of 15-minute historical data shall be stored in .csv file formats on an SFTP directory in the embedded device.

E. Circuit dashboards shall support importing of customer one-line or plan view graphic images and configurable MPM hotspot links on the graphic linked to MPM data.

F. Dashboards shall be configurable to support user preferred dashboard views.

G. Configure access to the MPM through the web server as directed by the Owner.

H. Configure dashboards to display energy consumption by panel and by mechanical equipment being monitored.

2.8 METERING DATA

A. Main System or Aggregate Data - The MPM shall report the present value of metering data representing a Main circuit. The Main circuit data can be either actual metered data or a virtual main representing the aggregated loads from the sub-meters. Readings for the Main System or Aggregate meter shall include:

1. Meter Name (32 Characters)
2. Watts, vars and VA per phase and system
3. Per phase Volts L-N and Volts L-L
4. Frequency
5. System Power Factor
6. kWh, forward and reverse
7. kvarh, Q1, Q2, Q3 and Q4
8. kVAh imported (Q1,Q4) and exported (Q2,Q3)
9. Block interval demand (1-60 minutes programmable)
   a. W Forward and Reverse
10. Peak interval demand with Date/Time of peak
    a. W Forward and Reverse
11. 1-minute Block interval demand (1 minute fixed)
    a. W Forward and Reverse
12. Minimum and Maximum readings including date and time of min/max shall be reported for:
    a. Watts, vars and VA per phase and system, Per phase Volts L-N and Volts L-L, Frequency and System Power Factor

B. Sub-meter readings - MPM shall report aggregated power and energy readings for combinations of channels configured as three phase, two pole and single pole sub-meters. Readings for the Sub-meters shall include:

1. Present RMS readings for Watts, Vars and VA (total)
2. Aggregated Power Factor
3. W and kWh, forward and reverse
4. var and kvarh, Q1, Q2, Q3 and Q4
5. kVAh imported (Q1,Q4) and exported (Q2,Q3)
6. Block interval demand (1-60 minutes programmable)
7. VA imported (Q1,Q2) and exported (Q2Q3)
8. Peak interval demand with Date/Time of peak
9. VA imported (Q1,Q2) and exported (Q2Q3)

C. Pulse Input Module – MPM reports for up to 80 Pulse input channels.

2.9 ALARMS

A. The MPM shall support alarms for the following functions: Demand Overload, Main Aggregate Power, Power Factor, Power Outage, Rate Alert, Submeter Power, Voltage Limits and Voltage Unbalance.

2.10 OUTPUTS

A. The MPM shall support up to 81 digital outputs. The number of outputs is scalable depending on the number and type of metering, pulse input counting and output modules installed in each MPM.

2.11 HISTORICAL DATA

A. MPM shall store interval-based Load Profile readings in non-volatile memory which can be retrieved by MPM configuration software or accessed by the Energy Portal Module.

1. Stored data for the Main System or Aggregate meter up to 60 configured submeters.
2. Stored data for up to 81 configured Pulse Input channel.

B. MPM shall store an alarm log.

2.12 HMI DISPLAY

A. Provide HMI display at the main switchboard.

B. HMI configuration shall not be required for each sub-meter. The HMI shall discover the configuration information automatically.

2.13 CLOUD MONITORING AND LOAD AGGREGATING SOFTWARE

A. Furnish, install, and configure cloud monitoring and load aggregating software to display all metered circuits.

B. Displayed information shall include:

C. Sub-meter name, demand readings including last interval and peak value with date/time of peak. Aggregated Power and Energy readings for any 1, 2 or 3 pole meters. Scaled Pulse counts for pulse metering.

D. Aggregate Loads to Display the following data:

1. Total Building Load
2. Building Lighting Load
3. Building Power Load
4. HVAC Power Load
5. Each metered roof top unit (RTU)
6. PV Production Load
7. Kitchen Load
8. Elevator Load
9. Standby Power Load
10. Emergency Power Load

PART 3 - EXECUTION

3.1 INSTALLATION

A. Coordinate, receive, mount, connect, [and place into operation] all equipment.

B. Install equipment in accordance with manufacturer's installation instructions.

1. Install relay cabinets in locations where audible noise is acceptable.
2. Use only with 75° C (167° F) copper wire at 75% ampacity.

C. Provide complete installation of system in accordance with Contract Documents.

D. Maintain performance criteria stated by the manufacturer without defects, damage, or failure.

E. Provide equipment at locations and in quantities indicated on Drawings. Provide any additional equipment required to provide control intent.

F. Furnish all conduit, wire, connectors, hardware, and other incidental items necessary for a properly functioning system as described herein and shown on the plans. The Electrical Subcontractor shall maintain performance criteria stated by the manufacturer without defects, damage, or failure.

G. Compliance: the Electrical Subcontractor shall comply with manufacturer's product data, including shop drawings, technical bulletins, product catalog installation instructions, and product carton instructions for installation.

H. Application of Power: Power shall not be applied to the system during construction and prior to turn-on unless specifically authorized by written instructions from the manufacturer.

3.2 SITE VERIFICATION

A. Verify that wiring conditions, which have been previously installed under other sections or at a previous time, are acceptable for product installation in accordance with manufacturer's instructions.

3.3 FIELD MEASUREMENTS

A. The Electrical Subcontractor shall be responsible for field measurements and coordinating the physical size of all equipment with the architectural requirements of the spaces into which they are to be installed.

3.4 INSPECTION

A. Inspect all material included in this contract prior to installation. Manufacturer shall be notified of unacceptable material prior to installation.

3.5 SITE PROTECTION

A. The Electrical Subcontractor shall protect installed product and finished surfaces from damage during all phases of installation including storage, preparation, testing, and cleanup.

3.6 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup checks according to the approved manufacturer's written instructions.

3.7 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct one 4-hour training session. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

End of Section

Section 26 09 43

NETWORK LIGHTING CONTROLS

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

1. Section Includes:
   a. Wireless occupancy/vacancy sensors.
   b. Wireless daylighting sensors.
   c. Wireless multi-sensors.
   d. Wired load control module with wireless communications.
   e. Plug load control.
   f. Zone relay control.
   g. Zone 0-10V dimming control.
   h. Wired receptacles with wireless communications.
   i. Wired wall stations with wireless communications.
   j. Power over Ethernet wired touchscreens.
   k. Wired luminaires with integrated sensors and wireless communications.
   l. Wired luminaires with wireless communications.
   m. Wireless gateway for area level programming and control.
   n. Supervisory Server for centralized configuration, monitoring and control.
   o. Integration interface for third party integration.

1.4 PROGRAMMING

A. Coordinate and obtain a written approval of system functionality from the Owner prior to programming.

B. Perform a walk-through with the Owner and demonstrate the system functionality.

C. Make any adjustments to system functionality after initial programming if necessary to achieve the desired functionality requested by the Owner.

D. Obtain a written final letter of acceptance from the Owner upon completion of system functionality programming and demonstration.

1.5 COORDINATION REQUIREMENTS

A. Coordination

1. Coordinate the placement of lighting area controllers and supervisory controller.
2. Coordinate the placement of sensors, wall stations and other user input devices.
3. Coordinate the placement of daylight sensors to achieve optimal daylight dimming.

B. Prewire meeting: conducted on-site or during design meeting with lighting control system manufacturers or designated representative prior to commencing work as part of the manufacturer's standard practice and startup services. Manufacturer to review with the installer:

1. Installation of lighting area controller and supervisory controller and locations.
2. Lighting control network wiring.
3. Network IT requirements.
4. Low voltage wiring requirements.
5. Lighting control integration requirements.
6. Lighting control system integration network wiring and connectivity.
7. Installer responsibilities.
8. Startup and training schedule and actions.

1.6 SUBMITTALS

A. Specification conformance document indicates whether the submitted equipment.

B. Meets specification exactly as stated.

C. Meets specification via an alternate means and indicate the specific methodology used.

D. Shop drawings; include:

1. Schematic (one-line diagram) will be specific to the project. Generic one-line diagrams will not be accepted. Provide drawing details for field installation that are specific to the project.
2. Wiring diagrams for typical application installation configurations.
3. Wiring diagrams for typical device installation configurations.

E. Product data: catalog data sheets with performance specifications demonstrating compliance with specified requirements and are specific to the project.

F. Sequence of operation to describe how each component operates and how any building wide functionality is achieved to exceed local energy code (California Title 24 2018, ASHRAE90.1 2016, IECC2018, or any newer versions of these codes.

G. Provide a description of the system.

H. System setup and programming to be provided by installer, certified technician or factory field service personnel.

1. This will involve an additional charge.

I. Follow-up by field services for "fine tuning" and additional configuration to occur approximately 90 days after system turnover.

1. This will involve an additional charge.

J. Re-occurring service contractor for site audit and continuing configuration on a 1, 2, or 3-year schedule after system turnover.

1. This will involve an additional charge.

1.7 CLOSEOUT SUBMITTALS

A. Sustainable design closeout documentation.

B. Wireless lighting control system manufacturer to provide an operation and maintenance manual that details the start-up procedure being performed including a process to follow, details on tests performed and an area that documents any test results.

1.8 QUALITY ASSURANCE

A. Product shall confirm to requirements outlined in NFPA 70.

B. Manufacturer: manufacturer shall have at least 10 years of experience in the manufacture of lighting control systems. Manufacturers that do not have at least 10 years of experience shall not be acceptable.

C. System components:

1. Listed by an OSHA Nationally Recognized Testing Laboratory specifically for the electronic ballast/driver loads. Provide evidence of compliance upon request.
2. Listed by FCC specifically for the required wireless communication protocols. Provide evidence of compliance upon request.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Store products in a clean, dry space in original manufacturer's packaging in accordance with manufacturer's written instructions until ready for installation.

1.10 WARRANTY

A. Comply with Section 260001.

B. The Electrical Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

C. Provide manufacturer's enhanced 5-year limited warranty:

1. 5-year limited warranty for the replacement of defective system components from the date of system shipment (except software application). Trellix Core hardware: One (1) year 100 percent parts coverage, one (1) year 100 percent manufacturer labor coverage.

D. Contractor shall provide limited workmanship warranty for one year from customer acceptance.

E. WaveLinx wireless fixtures with standard 0-10V dimmable ballast or driver module warranty is five (5) years. When purchased with the WaveLinx Connected Lighting system this warranty shall also be five (5) years by the lighting fixture manufacturer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers

1. Cooper Lighting, WaveLinx Connected Lighting (WCL) system.
2. Crestron Wireless Lighting Controls.
3. nLight Wireless Lighting Controls.
4. Or approved equal.

B. Basis of Design

1. Cooper Lighting, WaveLinx Connected Lighting (WCL) system.

2.2 LIGHTING CONTROL SYSTEM

A. General Requirements

1. The Lighting Control System shall meet all of the general criteria, operating characteristics and performance parameters specified herein.
2. The deployment team, defined as the electrical installer and commissioning agent, shall provide, connect and furnish all equipment necessary for the proper and complete operation and service of the Lighting Control System as indicated in the engineering drawings and specified herein.

B. The wireless lighting control system shall be capable of providing all the following functions for all lighting:

1. Continuous dimming and automatic on/off controls.
2. Indoor and outdoor occupancy control.
3. Indoor and outdoor vacancy control.
4. Indoor and outdoor daylight harvesting.
5. Outdoor load control.
6. Receptacle control.
7. Load management.
8. Multi-level scene control.
9. 7-Day scheduling.
10. Astronomic scheduling.
11. Demand Response.
12. Task Tuning.
13. Energy usage data reporting.

14. Mobile device configuration and control.
15. Automatic Code Commissioning.
16. Integration with third party systems via BACnet/IP and Public (REST) API.
17. Alarms monitoring console.

C. The wireless lighting control system shall be capable of continuous dimming and switching allowing each fixture to monitor its local environment and provide distributed control in response to environmental changes.

D. The wireless lighting control system shall provide network communication of all sensor and device data for all wireless devices including measured and calculated energy measurements, occupied/unoccupied status, scene status and daylight information.

E. The wireless lighting control system shall provide out-of-the-box functionality of all light fixtures with integrated sensors providing occupancy automatic on to 75% light level and automatic off after 20 minutes. Systems that do not include out-of-the-box functionality shall not be acceptable.

F. The wireless lighting control system shall provide a method for the installer to verify wireless communications and address all wireless devices with a single push button. Systems that require device addressing using a manual data entry method through software shall not be acceptable.

G. The wireless lighting control system shall provide visible indication on all wireless devices when as each wireless device joins the wireless network. Systems that do not provide a visual indicator per device to the installer shall not be acceptable.

H. The wireless lighting control system shall provide the capabilities for the installer to create a construction group of all wireless occupancy sensors and wireless wall stations to control all installed wireless light fixtures.

I. The wireless lighting control system shall be able to be completely programmed and configured using a mobile application. Systems that require web or pc software for configuration shall not be acceptable.

J. The wireless lighting control system shall allow addressed wireless light fixtures with integrated sensors to be identified (reverse-identified) by the sensor with laser, flashlight, IR remote, etc. Identified light fixtures shall provide visible indication on the mobile application. Systems that do not permit reverse identification method shall not be acceptable.

K. the wireless lighting control system shall allow wireless wall stations, receptacles, relays and remote sensors to be identified by simple pushbutton method on each device. Identified devices shall provide visible indication on the mobile application. Systems that do not permit reverse identification method shall not be acceptable.

L. The wireless lighting control system shall support standalone and networked topologies. In a standalone topology, the Wireless Area Controllers shall not be connected to an IP network. The user shall be able to program the standalone area controller via a mobile app. In a networked topology, the Wireless Area Controllers are connected to an IP network and bi-directionally communicate with a supervisory system.

M. The wireless lighting control system includes the following components:

1. Integrated sensors shall include passive infrared sensor, digital photocell, microprocessor, a wireless radio (IEEE 802.15.4), and a load controller for ON/OFF/DIM.
2. Relay Switchpack with 0-10V control shall contain a utility grade power meter chip and a latching relay to control 20-amp load and 120mA 0-10V sink. Device shall include LED indication and pushbutton for device override and identification.
3. Tilemount sensor kit shall include a digital photocell, microprocessor, a wireless radio (IEEE 802.15.4), and a load controller for ON/OFF/DIM. Tilemount Sensor kit shall be capable of installation in indoor ceiling tile applications, and standard junction boxes
4. Wall station shall be available in two (2) input power varieties:
    a. mains powered (120-277VACJ
    b. Both versions including the following features:
        1) Numerous button configurations, supporting small and large engraved buttons
        2) Individual button LED indication
        3) Universal light icon with raise/lower buttons
        4) Each button fully programmable for Area Scene or Zone control
        5) Wireless radio (IEEE 802.15.4)

5. Wireless ceiling sensor shall include the following features:
    a. Passive infrared motion sensor
    b. Photocell daylight sensor
    c. Wireless radio (IEEE 802.15.4)
    d. LED indication and pushbutton for device identification.

6. Touchscreen include the following feature:
    a. Send up to sixteen (16) pre-configured scene commands to an area
    b. Change the light level of a lighting zone or zones within an area
    c. Change the color temperature of a space via the associated correlated color temperature zone

7. Receptacle control shall include a constant hot and controlled plug output and include the following features:
    a. The receptacle control shall provide a single input for incoming power, devices that require constant hot and switched inputs shall not be acceptable.
    b. The receptacle control shall be clearly marked “Controlled” and with the NEMA defined controlled symbol.
    c. The receptacle control shall include a wireless radio (IEEE 802.15.4) to provide control and power measurement data.

8. Wireless Area Controllers shall support the following features:
    a. Wirelessly communicate (IEEE 802.15.4) with all wireless sensors, wireless wall stations, wireless relays, and wireless receptacles to coordinate control areas and zones.
    b. Wired communications through network switch to touchscreen interface to coordinate control areas and zones.
    c. Power over Ethernet port to power the Wireless Area Controller and allow the connection of a Wireless Area Controller to a local area network (LAN).
    d. 802.11 radio acting as a Wi-Fi AP allowing a mobile device to connect to the Wireless Area Controller to program the lighting system.
    e. 802.11 radio acting as a wireless gateway allowing a mobile application or a supervisory system to communicate with the Wireless Area Controller via a wireless local area controller.
    f. Up to 16 areas.
    g. Up to 16 zones per area.

h. Up to 16 scene configurations per area.
i. Up to 6 occupancy sets per area.
j. Multiple daylight sets per area.
k. Demand Response reduction values.
l. Scheduling configuration.
m. System backup and restore capabilities.
n. Automatic Code Commissioning.
o. Built-in astronomical clock.

9. Supervisory system shall allow users to monitor and control the lighting system from a central human machine interface as well as integrate with third party system via standard based interfaces. The supervisory system shall include the following feature:
   a. Ability to discover and connect to multiple Wireless Area Controllers.
   b. Aggregate data from the Wireless Area Controllers.
   c. Display the health data, i.e. devices faults notifications, and other system's notifications on a web-based HMI application.
   d. Provide troubleshooting tips for each detected fault that would allow the individuals responsible to maintain the system easily troubleshoot the system.
   e. Display the energy usage of the lighting system including controlled receptacles.
   f. Display the occupancy usage of the spaces based on the occupancy data gathered from the sensors.
      1) This may require an additional software license charge.
   g. Expose the data aggregated from the networked Wireless Area Controllers to third party system via BACnet/IP and Public (REST) API.
   h. Receive automatic demand response signal for load shedding from third party system via OpenADR, BACnet/IP and Public (REST) API and broadcast it to the connected Wireless Area Controllers.
      1) The OpenADR interface shall be listed in the OpenADR certified product database.
   i. Send manual overrides/actions.
   j. Create / manage lighting system schedules.
   k. View areas/zones and devices on a floor plan.
   l. Manage user accounts and user roles.
   m. Manage the supervisory system's software upgrades as well as Wireless Area Controllers.
   n. Backup/restore the Supervisory System (OS, application and database).

2.3 LIGHTING CONTROL APPLICATIONS

A. Minimum lighting control performance required, unless local energy code is more stringent.

B. Occupancy/vacancy requirements - provide an occupancy/vacancy sensor with manual on/ automatic off or automatic on/ automatic off functionality in all spaces. Manual on vacancy sensors should be used for any enclosed space with a manual on switch that does not require hands free operation. Spaces with multiple occupants or where line of sight might be obscured ceiling or corner mount sensors and manual wall stations would be required. Automatic on of lighting via occupancy sensor cannot exceed 50% of lighting. Systems that do that allow the user to select occupancy or vacancy mode shall not be acceptable.

C. Bi-level switching - provide multi-level switching and/or variable dimming for maximum energy savings.

D. Task lighting / receptacle control - provide automatic shut off of non-essential plug loads and task lighting in all spaces. Provide manual on or automatic on of receptacles whenever spaces

are occupied. Receptacle control will only be shut off when no occupancy is detected within the space. Systems that do not provide receptacle control for a full 20-amp circuit shall not be acceptable.

E. Daylight zones - primary side-lit or top-lit areas within an enclosed space shall be controlled separately and automatically by individual integrated daylight sensors. Adjustments to the daylight zones must be provided by a simple to use, intuitive mobile application.

F. Provide smooth and continuous daylight dimming for areas marked on drawings. Daylighting control system may be designed to dim electric light to the lowest light level and off.

G. Provide the ability to adjust the high-end and low-end trim of the dimmers to ensure the lighting automatically provides energy saving even when daylighting calls for full illumination.

H. Provide the ability for the dimmers and the relays to function separately. Systems where the 0-10v dimmers and relays are tied together reduce design capabilities and shall not be acceptable.

I. Shall be capable of automatically responding to a demand response signal and adjusting the lighting level, without the need of programming or software. Systems that require software or commissioning to provide demand response integration shall not be acceptable.

J. Additional controls:

1. Provide occupancy or vacancy sensors (Auto On or Manual On) for any enclosed office, conference, meeting or training rooms. Spaces with multiple occupants or where line of sight may be obscured require ceiling or wall/corner mounted sensors with Manual On switches.
2. Conference, meeting, training, auditoriums and multi-purpose rooms shall have controls that allow for scene based and independent control of each output. Rooms larger than 300 square feet shall support at least four (4) pre-set lighting scenes. Occupancy or vacancy sensors shall ensure all lighting, receptacles.
3. Egress lighting control shall be integral to the system. The system shall provide an automatic control of adjacent corridor and/or egress lighting based upon room occupancy. Systems that do not ensure that adjacent corridor and/or egress lighting is controlled with room occupancy shall not be acceptable.
4. Shall be able to communicate with third party system such as a building automation system by means of native BACnet/IP communication hosted on the supervisory system. The supervisory system shall be on the same subnet as the third-party system.
5. Shall be able to communicate with third party systems such as IoT platforms or AV systems by means of restful API commands via the public API interface hosted on the supervisory system. The supervisory system shall be able to communicate to the third system via the IP network provided by the customer through the proper ports.

2.4 CYBERSECURITY

A. The network connectable products within the Wireless Lighting Control system must be UL2900-1 listed to the Standard for Software Cybersecurity for Network-Connectable Products. Wireless Lighting Control Systems that fail to meet this requirement will not be accepted.

2.5 CONNECTED DEVICES

A. Load control devices

1. Product: WaveLinx Field Relay Switchpack with 0-10 [WSP-MV-010] for normal circuits and [WSP-MV-010-EM] for emergency circuits.
   a. Plenum rated.
   b. Integrated, self-contained unit consisting internally of an isolated load switching control relay [and a power supply to provide low voltage power].
   c. 20-amp 120/277VAC General Purpose.
   d. 16-amp 120/277VAC electronic ballast (LED load).
   e. Single class 2 0-10V dimming output {IEC 60929 Annex E) sinks up to 120mA per (40 pA max per circuit leakage to line).
   f. 0-10V output supports up to 60 ballasts/drivers that draw a standard 2mA each.
   g. Calculated energy consumption data available through Trellix.
   h. Shall be compatible with electronic ballast, LED, incandescent, magnetic or electronic low voltage, and magnetic or electronic fluorescent, as well as motor loads.
   i. Shall be capable of controlling up to 20-amp receptacle or plug loads.
   j. Controls incorporate non-volatile memory. Settings and parameters saved in protected memory shall not be lost should power be interrupted and subsequently restored.
   k. Relay Switchpack shall be FCC certified.
   l. Relay Switchpack shall be a Class 1 device
   m. If the Field Relay Switchpack is utilized to control plug loads instead of WaveLinx Receptacle [WR-20]:
      1) Receptacle control shall include a constant hot and controlled outlet at each duplex receptacle designated to be controlled on the drawings.
      2) Wire the receptacle so that only the top half of the duplex receptacle shall be switched.
      3) The receptacle control shall be clearly marked “Controlled” and with the NEMA defined controlled symbol.
      4) Only the receptacles designated to be controlled on the drawings shall be switched.
      5) Where controlled and non-controlled receptacles are fed from the same circuit, the non-controlled receptacles shall be wired ahead of the Relay Switchpack so that they are not switched.

2. Product: WaveLinx Receptacle [WR-20]
   a. The basis of design for controlled receptacles is the WR-20. The use of field relay switchpack shall be permissible if the receptacles are wired as described in 2.5A.1.m. above.
   b. Integrated, self-contained unit providing a constant hot plug connection and a controlled plug connection.
   c. 20-amp 120VAC constant hot.
   d. 20-amp 120VAC controlled load.
   e. Controlled load plug shall be labelled with "Controlled" and NEMA standard symbol for controlled plug loads.
   f. Controlled outlet calculated energy consumption data available through Trellix.
   g. Shall provide LED indication of status and wireless communication as well as override button.
   h. Controls incorporate non-volatile memory. Settings and parameters saved in protected memory shall not be lost should power be interrupted and subsequently restored.
   i. WaveLinx Receptacle shall be FCC certified.
   j. WaveLinx Receptacle shall be a Class 1 device.

2.6 CONTROL DEVICES

A. Product: WaveLinx Line-Voltage Wall station [W1L-*],[W1L-RL-*],[W2L-*],[W2L-RL-*],[W3L-*],[W2S-*],[W2S-RL-*],[W4S-*],[W4S-RL-*],[W5S-*],[W6S-*]

1. Mains powered wireless wall station providing multi-level control of an area or zone.
2. 120-1277VAC input.
3. Shall provide individual button LED indication of status and wireless communication as well as selected button.
4. Controls incorporate non-volatile memory. Settings and parameters saved in protected memory shall not be lost should power be interrupted and subsequently restored.
5. WaveLinx Line-Voltage Wall station shall be FCC certified.
6. WaveLinx Line-Voltage Wall station shall be a Class 1 device.
7. Wireless momentary pushbutton switches in 2, 3, 4, 5 and 6 button configurations; available in white, ivory, grey and black; compatible with wall plates with decorator opening. WaveLinx Line-Voltage Wall stations shall include the following features:
   a. Multi-level scene selection
   b. Scene raise/lower
   c. Toggle ON/OFF
   d. Removable buttons for field replacement with engraved buttons and/or alternate color buttons [ENGRV-"BTNl-*], [ENGRV-*BTNS-*]. Button replacement may be completed without removing the switch from the wall.
   e. Intuitive button labeling to match application and load controls.
   f. Pre-defined digital button configurations. Each wall station is shipped with predefined digital button configurations which are automatically mapped to specific area/zone controls when added to an area in the WaveLinx Mobile Application.
8. Multiple WaveLinx wall stations may be installed in an area by simply connecting them to the WaveLinx network. No additional configuration will be required to achieve multi-way switching.
9. WaveLinx Line-Voltage Wall stations are delivered with pre-defined functions including, raise, lower, Half Lights, Full Lights, Read, Relax, Dimmed, Night, manual and scene control.
10. WaveLinx Line-Voltage Wall stations may also be delivered with field programmable generic labeled buttons such as Scene 1, Scene 2, etc.
11. Custom engraving for wall station button labels.

B. Product: Touchscreen [TSE57-WLX-B]

1. Power over Ethernet (PoE - IEEE 802.3af) powered.
2. Touchscreen to Wireless Area Controller communications via Ethernet.
3. 5.7" diagonal capacitive touch display screen.
4. Installs to standard single gang wall box.
5. Touchscreen to provide the following functions:
   a. Send user-defined or pre-configured scene commands to an area.
   b. Change light levels for lighting in an area or zone.
   c. Change color temperatures for lighting in an area or zone.

2.7 CONNECTED SENSORS

A. Ceiling mounted or fixture integrated sensors.

1. Product: WaveLinx Ceiling Sensor [CWPD-1500]

a. Occupancy Sensing:
   1) PIR multiple segmented lens, with internal grooves to eliminate dust and residue build-up.
   2) Products tested in identical manner, complaint to NEMA WD 7 -2011 Occupancy Motion Sensors Standards.
   3) Sensor shall have time delays from 10 to 20 min.
   4) Sensor battery life shall be 10 years based on approximately 30 activations and wireless signals per day.
b. Daylight Sensing:
   1) Open loop daylight sensor.
   2) 100-900lux.
   3) Light input within 60" cone.
c. Power failure memory:
   1) Controls incorporate non-volatile memory. Settings and parameters saved in protected memory shall not be lost should power be interrupted and subsequently restored.
   2) Sensor is battery powered by two (2) AA standard alkaline batteries.
d. Sensor wireless reporting:
   1) Battery life through the WaveLinx Mobile Application.
   2) Occupancy status.
   3) Ambient light level.
e. All sensors shall provide an LED as a visual means of indication at all times to verify that motion is being detected during both testing and normal operation.
f. Sensor shall wirelessly transmit occupancy; light level, power to the WaveLinx Wireless Area Controller which allows the data to be stored in a central location on premises and displayed via the WaveLinx Mobile Application and Trellix software.
g. Sensors shall be fully adaptive with the ability to have the sensitively and timing to be remotely adjusted to ensure optimal lighting control for any use of the space.
h. Sensors have remotely adjustable settings for dimming levels, occupied/unoccupied light levels, occupancy/vacancy sensing, and sensitivity to changes in motion and changes in ambient light levels.
i. Sensors may remotely adjust light output to reduced levels and remain at that reduced level for an adjustable time period before turning off when a space is vacant.
j. Programming is stored in each sensor in addition to the Wireless Area Controller. Sensors operate independently of from Wireless Area Controller, so there cannot be single point failure. Systems must operate so there is no single point of failure.

2. Product: WaveLinx Integrated Sensor [SWPD1]
   a. Sensing mechanism:
      1) [Infrared]: Utilize multiple segmented lens, with internal grooves to eliminate dust and residue build-up.
      2) [Daylight]: Utilize integrated daylight sensor to provide closed loop daylight dimming control. Each WaveLinx Integrated Sensor provides an individual daylight dimming zone to provide highly accurate daylight levels at the work surface throughout the entire space.
   b. Power failure memory:
      1) Controls incorporate non-volatile memory. Settings and parameters saved in protected memory shall not be lost should power be interrupted and subsequently restored.
   c. Products tested in identical manner, complaint to NEMA WD 7 -2011 Occupancy Motion Sensors Standards.
   d. Sensor shall have time delays from 10 to 20 min.

e. Sensor shall provide unique daylight calibration considering light level at the sensors, work surface and integrated luminaire light output.
f. All sensors shall provide an LED as a visual means of indication to verify that motion is being detected during both testing and normal operation.
   1) Green LED indication when sensor is in out-of-the-box operation mode.
   2) White LED indication when sensor has been connected to the WaveLinx lighting control system.
g. Test mode - fifteen second time delay.
h. Walk-through mode.
i. Sensors are RoHS compliant.
j. Sensor shall provide out-of-the-box functionality of occupancy detection, directly controlling integrated fixture.
   1) Occupied default light level is 75%.
   2) Unoccupied default light level is OFF.
   3) Occupancy default time out is 20 minutes.
k. Sensors shall monitor changes in occupancy, changes in ambient light levels and communicate digital control commands to light fixtures according to a control strategy.
l. Sensor shall wirelessly transmit occupancy and light level to the WaveLinx Wireless Area Controller which allows the data to be stored in a central location on premises and displayed via the WaveLinx Mobile Application and Trellix software.
m. Calculated energy consumption data available through Trellix.
n. Sensors shall be fully adaptive with the ability to have the sensitivity and timing to be remotely adjusted to ensure optimal lighting control for any use of the space.
o. Sensors have remotely adjustable settings for dimming levels, occupied/unoccupied light levels, occupancy/vacancy sensing, and sensitivity to changes in motion and changes in ambient light levels.
p. Sensors may remotely adjust light output to reduced levels and remain at that reduced level for an adjustable period before turning off when a space is vacant.
q. Default programming is stored in each sensor in addition to the Wireless Area Controller. Sensors operate independently of from Wireless Area Controller, so there cannot be single point failure. Systems must operate so there is no single point of failure.

3. Product: WaveLinx Integrated Sensor [WAA]
   a. Sensing mechanism:
      1) [Infrared]: Utilize multiple segmented lens, with internal grooves to eliminate dust and residue build-up.
      2) [Daylight]: Utilize integrated daylight sensor to provide closed loop daylight dimming control. Each WaveLinx Integrated Sensor provides an individual daylight dimming zone to provide highly accurate daylight levels at the work surface throughout the entire space.
      3) [Location]: Utilize additional internal radio capable of offering real time location services (upgrade and specific hardware required).
   b. Power failure memory:
      1) Controls incorporate non-volatile memory. Settings and parameters saved in protected memory shall not be lost should power be interrupted and subsequently restored.
   c. Products tested in identical manner, complaint to NEMA WD 7 -2011 Occupancy Motion Sensors Standards.
   d. Sensor shall have time delays from 10 to 20 min.
   e. Sensor shall provide unique daylight calibration considering light level at the sensors, work surface and integrated luminaire light output.

f. All sensors shall provide an LED as a visual means of indication to verify that motion is being detected during both testing and normal operation.
   1) Green LED indication when sensor is in out-of-the-box operation mode.
   2) White LED indication when sensor has been connected to the WaveLinx lighting control system.
g. Test mode - fifteen second time delay.
h. Walk-through mode.
i. Sensors are RoHS compliant.
j. Sensor shall provide out-of-the-box functionality of occupancy detection, directly controlling integrated fixture.
   1) Occupied default light level is 75%.
   2) Unoccupied default light level is OFF.
   3) Occupancy default time out is 20 minutes.
k. Sensors shall monitor changes in occupancy, changes in ambient light levels and communicate digital control commands to light fixtures according to a control strategy.
l. Sensor shall wirelessly transmit occupancy status and light level to the WaveLinx Wireless Area Controller which allows the data to be stored in a central location on premises and displayed via the WaveLinx Mobile Application and Trellix software.
m. Calculated energy consumption data available through Trellix.
n. Sensors shall be fully adaptive with the ability to have the sensitivity and timing to be remotely adjusted to ensure optimal lighting control for any use of the space.
o. Sensors have remotely adjustable settings for dimming levels, occupied/unoccupied light levels, occupancy/vacancy sensing, and sensitivity to changes in motion and changes in ambient light levels.
p. Sensors may remotely adjust light output to reduced levels and remain at that reduced level for an adjustable period before turning off when a space is vacant.
q. Default programming is stored in each sensor in addition to the Wireless Area Controller. Sensors operate independently of from Wireless Area Controller, so there cannot be single point failure. Systems must operate so there is no single point of failure.

4. Product: WaveLinx Tilemount Sensor Kit [WTA]
   a. Sensing mechanism:
      1) [Infrared]: Utilize multiple segmented lens, with internal grooves to eliminate dust and residue build-up.
      2) [Daylight]: Utilize integrated daylight sensor to provide closed loop daylight dimming control. Each WaveLinx Integrated Sensor provides an individual daylight dimming zone to provide highly accurate daylight levels at the work surface throughout the entire space.
      3) [Location]: Utilize additional internal radio capable of offering real time location services (upgrade and specific hardware required).
   b. Power failure memory:
      1) Controls incorporate non-volatile memory. Settings and parameters saved in protected memory shall not be lost should power be interrupted and subsequently restored.
   c. Tilemount sensor connects to a control module which supports up to 3 amps of connected fixtures.
   d. Tilemount is designed to be installed in a ½” or ¾” ceiling tile within 54" (137cm) of the control module and connected fixtures.
   e. Sensor shall provide unique daylight calibration considering light level at the sensors, work surface and integrated luminaire light output.
   f. All sensors shall provide an LED as a visual means of indication and diagnostics.
   g. Sensors are RoHS compliant.

h. Control Module:
   1) Sensor shall connect to a 0-10V dimmable ballast or driver via a control module or connect to a WaveLinx enabled driver without the use of WaveLinx control module.
   2) Sensor shall connect to a controller via a low voltage cable for interior applications.
   3) If power dropouts in the event of a brown-out or black-out, when power is restored, the lighting system should recover quickly and automatically return to the last lighting levels. A momentary interruption (1 or 2 seconds) of power should not cause extended periods (20 seconds or more) without lighting while the system reboots and all other electrical equipment is back on.
   4) Control Module shall be installed by luminaire manufacturer and is shipped as an integral component to the luminaire.
i. Sensor shall be FCC certified.
j. Sensor shall be a Class 2 device.
k. System shall support user initiated manual demand response and utility or BMS initiated automatic demand response.

5. Control Module Components:
   a. Calculated energy consumption data based on maximum connected power available through Trellix.
   b. Controller to include latching relay, to decrease power requirements of the power pack.
   c. Operate Bounce Time: 3 milli-seconds (MAX).
   d. Max Switching Voltage 277VAC and 125VDC.
   e. Insulation Rating: Class B and Class F.
   f. Operations:
      1) Control Module and Sensor shall communicate energy usage Wireless Area Controller.
   g. Listed to UL 916.
   h. FCC Part 15 Class A certified.
   i. Manufacturer to pre-wire control module in fixture.
   j. Control module shall be plenum rated.
   k. Connection between sensors and control module shall be Class 2, 18-24 AWG, stranded or solid depending on the application U.L Classified, PVC insulated or TEFLON jacketed cable suitable for use in plenums.

B. Wireless Outdoor Load Control Module

1. Product: WaveLinx Outdoor Load Control [WOLC]
   a. Power failure memory:
      1) Controls incorporate non-volatile memory. Settings and parameters saved in protected memory shall not be lost should power be interrupted and subsequently restored.
   b. Control wireless reporting:
      1) Load status.
   c. Outdoor load control shall turn ON/OFF/DIM connected outdoor luminaire based on wireless communications signal from the WaveLinx Wireless Area Controller.
   d. The WaveLinx Wireless Area Controller shall control the Outdoor load controller using the following:
      1) Time Schedule.
      2) Astronomic time schedule.
      3) Manual pushbutton from a connected wall station.

4) BACnet command.
5) API command.

e. Controller shall wirelessly transmit; light level, power to the WaveLinx Wireless Area Controller which allows the data to be stored in a central location on premises and displayed via the WaveLinx Mobile Application.
f. Controller shall have remotely adjustable settings for dimming levels, time based light levels.
g. Controller shall have the ability to remotely adjust light output to reduced levels and remain at that reduced level for an adjustable time period before turning off when a space is vacant.
h. Default programming is stored in each sensor in addition to the Wireless Area Controller. Sensors operate independently of from Wireless Area Controller, so there cannot be single point failure. Systems must operate so there is no single point of failure.

2.8 CONNECTED SPACES

A. WaveLinx Wireless Area Controller [WAC-POE]

1. Spaces shall be equipped with a control device to automatically shut off lighting in those areas. This automatic control device shall function on either:
   a. A timeclock scheduling basis where the interior and exterior lights controlled by the Wireless Area Controller are changed based on the time of day or the astronomic (sunrise and sunset).
      1) The astronomical timeclock shall be integrated into the Wireless Area Controller and shall not require any internet connection to maintain its time.
      2) The timeclock programming and time clock settings shall be retained after a power loss.
      3) The timeclock shall allow weekly recurrences.
      4) Time clock events can be scheduled to:
         a) Set areas to desired scenes.
         b) Zone light levels to the desired light level.
         c) Zone light levels when occupied.
         d) Zone light levels when unoccupied.
   b. An occupancy basis where the interior and exterior lights controlled by the Wireless Area Controller are changed based on the occupancy set status. The occupancy set is composed of one or more occupancy sensors and it shall turn lighting off within 20 minutes of an occupant leaving a space.
   c. A manual command basis where a user or a program send an override command using a wireless wall station, the mobile application or via BACnet/IP or Public API. The BACnet/IP and Public API signal will be received via the Insight Manager/supervisory system.

2. Provide Wireless Area Controllers [WAC-POE] in the locations and capacities as indicated on the plans and schedules. Each Wireless Area Controller [WAC-POE] shall have the following capabilities:
   a. The Wireless Area Controller [WAC-POE] is a server-class gateway that discovers, programs and manages WaveLinx connected devices, connected sensors and connected Apps.
   b. The Wireless Area Controller shall be a UL-2900 listed product where UL-2900 is a standard Cybersecurity for Network Connectable Products.
   c. Uses industry standard HTTPS security with AES-128 encryption safeguards the integrity of the entire system. Backups prevent data loss and restore fixtures to

operational modes. It constantly monitors areas to ensure that spaces are managed according to the assigned user preferences and tasks being performed.

d. Using standardized Power over Ethernet (IEEE802.3af) input, enables building PoE network switches (by others) or a PoE injector [WPOE-120] (accessory by Cooper Lighting Solutions) for power and network connection.
e. Maximum Ethernet (CAT6A or better) cable distance between the Wireless Area Controller and a network PoE switch is 328 feet (100 meters). Care shall be taken when routing the cable to not exceed the 328 feet (100 meter) limitation including travel distance up and down structures.
f. Wi-Fi access point and wireless client capabilities. Wi-Fi capabilities are automatically disabled if the Wireless Area Controller is physically connected to a building LAN and receives an IP address. Systems that allow multiple simulations methods of network connection (Wi-Fi & LAN) shall not be acceptable.
g. 2.4 GHz Transceiver for IEEE 802.15.4 wireless radio for communication to connected devices and sensors.
h. Shall support AES 128-bit encryption.
i. LED indicators for status of various wireless radios and communications.
j. Shall be FCC Part 15 Class A, RoHS certified.
k. Wireless Area Controller connection cables shall be plenum rated.
l. Shall be Class 2 devices.
m. Construction Grouping
    1) PAIR button to allow automatic creation of Construction Group allowing simplified automatic control of all connected devices and sensors.
    2) The patent-pending Construction Grouping mode permits contractors to complete a quick system start-up to confirm that the devices have been installed correctly, instead of waiting for factory-trained technicians to get the lights on a project in working order. Contractors follow a simple process to pair the wireless devices with the appropriate WAC and initiate occupancy-based lighting control functionality. This saves lighting energy during the construction phase of the project by ensuring that the lights are turned off when the area is unoccupied.
    3) Construction grouping provides visual indication to the installer that devices have received wireless communication from the Wireless Area Controller and received a unique individual address. Systems that do not provide visual indication of device connection to the wireless network shall not be acceptable.
    4) Construction grouping provides automatic grouping of connected devices to provide simple occupancy-based and wall station control of all devices, without the need of a factory trained technician. Systems that require special software or training to group wireless devices shall not be acceptable.
n. Scalability and Data Integrity
    1) The Wireless Area Controller can be deployed as a dedicated installation managing up to 150 wireless device (connected devices, connected sensors). When deployed as a dedicated installation the Wireless Area Controller acts as a local wireless access point for Wi-Fi connection method to the WaveLinx Mobile Application.
    2) The Wireless Area Controller can be deployed as a network installation managing up to 150 wireless devices (connected devices, connected sensors) per Wireless Area Controller. When deployed as a network installation the Wireless Area Controller connects to the building LAN or wireless network as a client using DHCP. The maximum number or Wireless Area Controllers on the building network is dependent upon the building network configuration.

B. Trellix Core [ELS-TCPRO2, ELS-TCENT2, ELS-TCVRT2]

1. The Trellix Core shall support up to 500 Wireless Area Controllers. The entry level model (Trellix Core Pro) shall support up to 20 Wireless Area Controllers while the enterprise level model (Trellix Core Enterprise) shall support up to 500 Wireless Area Controllers.
2. The Trellix Core shall support all Trellix applications and 3"" party interfaces (BACnet/IP, REST API, OpenADR).
3. The Trellix Core shall be d UL-2900 listed product where UL-2900 is a standard Cybersecurity for Network Connectable Products.

2.9 CONNECTED APPLICATIONS

A. WaveLinx Mobile Application [WAPP]

1. Administrative programming and editing may be conducted via an intuitive iOS or Android mobile application.
2. WaveLinx Mobile Application shall support the following features:
   a. Network discovery of multiple Wireless Area Controllers.
   b. Naming and identification of Wireless Area Controllers.
   c. Unique administrative login credentials for each Wireless Area Controller.
   d. Discovery of wireless devices per Wireless Area Controller (Find Devices).
   e. Creation of up to sixteen (16) areas per Wireless Area Controller.
   f. Creation of up to sixteen (16) zones per area.
   g. Creation of up to six (6) occupancy sets per area.
   h. Creation of daylight sets for each integrated luminaire.
   i. Creation of Demand Response values for each area
   j. Definition of scene values for each area.
   k. Definition of schedules for each Wireless Area Controller
   l. Blink identification and reverse identification of each connected devices and sensor.
   m. Identified connected devices and sensors will indicate on the WaveLinx Mobile. Application their selection by the device icon pulsing on the screen.
   n. Ability to utilize drag and drop, multi select and filter capabilities for easy association of connected devices and sensors to a defined area.
   o. Automatic Code Commissioning features include:
      1) Automatic association of all devices added to an area to provide a California Title 24 code compliant sequence of operations
      2) All occupancy sensors are joined together to provide an Automatic ON to 50% light level.
      3) All occupancy sensors are joined together to provide an Automatic OFF of all luminaires and plug loads after 20 minutes of with no occupancy detected.
      4) Automatic closed loop daylighting to approximately 500 lux (46 footcandles).
      5) Automatic wallstation button mapping providing the dominant button providing a 50% light level all other buttons provide multi-level dimming control from 30%-100%.
      6) Automatic display of area power measurement data.
      7) Automatic Demand Response of 20%.
      8) Additional screens if needed to adjust Automatic Code Commissioning settings.

B. Trellix

1. The application shall be accessible via HTML5 compatible web browsers such as Microsoft Edge, Google Chrome and Apple Safari.
2. The application shall support multiple computing device types, i.e. smartphones, tablets, laptops and desktop computers.
3. The software application shall support touch interaction.
4. The application shall utilize HTTPS (industry-standard certificate-based encryption and authentication for security).
5. The system shall display the location of devices, zones and areas on a floor plan (jpeg or svg).
6. The system shall allow users to monitor and control the lights:
   a. Area lights can be monitored for on/off status.
   b. Area lights can be modified to a predefined scene or defined light level.
   c. Zone lights can be monitored for on/off status.
   d. Zone lights can be modified to defined light level.
   e. Individual control devices can be monitored for on/off status.
   f. Individual control devices can be modified to define light levels or on/off status.
7. The system shall allow users to monitor and control the light schedules:
   a. Display the light schedule on a daily, weekly or monthly calendar.
   b. Configure light schedule based on a specific time of day or astronomic time clock event.
8. The system shall display system's fault in near real-time. System faults include loss of communication with the Wireless Area Controller, wireless wall station, wireless ceiling sensor, wireless switchpack, wireless daylight sensor, wireless control module and low battery alarms.
9. The system shall log all current and past system faults to provide better insight of the system's health.
10. The system shall offer context-sensitive troubleshooting tips for each alarm.
11. The system shall be able to send e-mail notifications to subscribe users for each fault. The user shall provide the SMTP server information to allow the Trellix to send out email notifications.
12. The system shall display the energy usage for the buildings controlled by the WaveLinx system:
    a. The user shall be able to filter the data based on the building hierarchy, i.e. building, floors, areas and zones as well as the source type, i.e. lighting and/or receptacles.
    b. The system shall be able to collect energy usage data for 13 consecutive months.
    c. The user shall be able to change the period for the energy usage, i.e. last 24 hours, last 7 days, last 30 days, last 3 months, last 12 months.
    d. The user shall be able to see the energy savings generated by the lighting system at minimum in kWh for the selected period.
    e. The user shall be able to see the average energy savings for the selected period.
13. The system shall display the space for the buildings controlled by the WaveLinx system:
    a. The user shall be able to filter the data based on the building hierarchy, i.e. building, floors, areas and zones.
    b. The system shall be able to collect space usage data for 13 consecutive months.
    c. The system shall display the space usage based on 24 hours or working hours.
    d. The system shall display in sorting order the least to most used spaces.
    e. The system shall display on a floorplan the space usage for each area based on selected period.

C. BACnet Interface:

1. The BACnet/IP interface shall support the following capabilities
   a. BACnet integrator can monitor:
      1) Area scene
      2) Area energy usage
      3) Dimming zone level (0-100%)
      4) On/off zone level (on/off)
      5) Occupancy sensor's occupied/unoccupied status
      6) Daylight sensor's level
   b. BACnet integrator can command:
      1) System-wide Demand Response enable/disable
      2) Area scene
      3) Dimming zone level (0-100%)
      4) On/off zone level (on/off)
      5) Occupancy sensor

2. The system shall be able to allow users to select which object types the system shall expose, i.e. Area, Zones, input devices and output devices.
3. The system shall be able to generate the electronic PICS document and allow users to be able to send the PICS document to the proper stakeholders.

D. The Public API shall support the following capabilities

1. The Public API interface shall support the following get/put capabilities:
   a. Get:
      1) Building hierarchy information (areas, zones, devices)
      2) Area scene
      3) Area energy usage
      4) Dimming zone level (0-100%)
      5) Zone level (on/off)
      6) Occupancy sensor's occupied/unoccupied status
      7) Occupancy set status
      8) Daylight sensor's level
   b. Put:
      1) System-wide Demand Response enable/disable
      2) Area scene
      3) Dimming zone level (0-100%)
      4) Zone level (on/off)
      5) Occupancy sensor

E. OpenADR interface shall support the following capabilities

1. Register the OpenADR interface of the WaveLinx system with a utility's Demand Response Automation Server (DRAS).
2. Initiate load shed event using OpenADR protocol in an auto-Demand-Response event without additional interfaces or gateways.

2.10 BMS INTEGRATION

A. Building Management System (BMS) Integration

1. Provide integration with the BMS through BACnet/IP.
2. The integration of the Lighting Control System (LCS) and Building Management Systems (BMS) shall meet the objectives listed as follows:

a. Consolidated Device Status: The operational status of all system devices shall be consolidated to a central repository.
b. Consolidated Energy Reporting: The energy consumption of all system devices shall be published to a consolidated central repository.
c. Asset Tracking: The bill of materials of each system shall be consolidated to a central repository.
d. Event calendar: The maintenance schedule for each system shall be consolidated to a central repository.
e. Shared Hardware: Devices common to multiple systems shall be shared in order to reduce overall part quantity. (Occupancy sensors in the lighting system shall be used to signal room/space occupancy status to the HVAC system by sharing data among both systems).
f. Automated Response: Events in any system shall automatically trigger a programmed, user defined response in appropriate other systems. (For example, a demand response event in the HVAC system shall automatically initiate a demand response routine in the LCS).
g. Central Access: The user interface shall be consolidated into a single window to perform major daily operator functions.
h. Parking Lot Control: Coordinate with the BMS vendor to enable the control of the parking lot lighting through the BMS.

3. Carry 40-hours to facilitate integration between LCS and BMS. Coordinate requirements with the BMS vendor.

2.11 FIRE ALARM INTEGRATION

A. In the event of a fire alarm, the LCS will:

1. Turn ON all the light fixtures and override all switches/programming.
2. Turn OFF all controlled receptacles controlling the projector circuits.
3. Turn OFF all field relays associated with the in-ceiling instructional audio system.

B. Once the fire alarm panel is reset, the LCS will resume normal operation.

2.12 GENERATOR INTEGRATION

A. In the event of a power failure or when the generator is running, the LCS will:

1. Turn ON all the light fixtures and override all switches/programming.

B. When the power is restored, or the generator is turned off, the system will resume normal operation.

2.13 INTRUSION DETECTION SYSTEM (IDS) INTEGRATION

A. In the event of an intrusion alarm, the LCS will:

1. Turn ON all the light fixtures and override all switches/programming.

B. Once the intrusion detection panel is reset, the LCS will resume normal operation.

2.14 LIGHT LEVEL PROGRAMMING

A. General,

1. All dimmable light fixtures shall be programmed for a maximum 80% light output unless higher output is needed to meet footcandle levels.
2. All occupancy sensors shall be programmed for vacancy mode (requires manual activation of wall switch to turn ON light fixtures).

B. Classroom

1. Occupied Level: 80% LPD (Light Power Density). Achieve average illumination at desk level of between 35-50 footcandles with minimum of 25 footcandles at any point more than three feet from any wall.
2. AV Mode: Achieve an average illumination at the desk level of between 10-20 footcandles for any point in the room greater than three feet from the side walls, 10 feet from the front wall and six feet from the back wall, while limiting vertical illumination on the projection screen to no more than seven footcandles at any point on the screen.
3. Quite Time: override the multi sensor and achieve average illumination at desk level of between 35-50 footcandles with minimum of 25 footcandles at any point more than three feet from any wall for a preset time of one hour.
4. Vacancy Level: 0% LPD

C. Common Area

1. Occupied Level: 80% LPD (Light Power Density). Achieve average illumination at desk level of between 35-50 footcandles with minimum of 25 footcandles at any point more than three feet from any wall.
2. AV Mode: Achieve an average illumination at the desk level of between 10-20 footcandles for any point in the room greater than three feet from the side walls, 10 feet from the front wall and six feet from the back wall, while limiting vertical illumination on the projection screen to no more than seven footcandles at any point on the screen.
3. Quite Time: override the multi sensor and achieve average illumination at desk level of between 35-50 footcandles with minimum of 25 footcandles at any point more than three feet from any wall for a preset time of one hour.
4. Vacancy Level (Normal Business Hours): 50% LPD
5. Vacancy Level (Non-Business Hours): 0% LPD

D. Office/Conference

1. Occupied Level: 80% LPD
2. Vacancy Level: 0% LPD

E. Bathroom

1. Occupied Level: 80% LPD
2. Vacancy Level (Normal Business Hours): 10% LPD
3. Vacancy Level (Non-Business Hours): 0% LPD

F. Utility/Storage/Maintenance

1. Occupied Level: 80% LPD
2. Vacancy Level: 0% LPD

G. Cafeteria

1. Occupied Level: 80% LPD
2. Vacancy Level (Normal Business Hours): 50% LPD
3. Vacancy Level (Non-Business Hours): 0% LPD

H. Gym

1. Occupied Level: 80% LPD
2. Vacancy Level (Normal Business Hours): 10% LPD
3. Vacancy Level (Non-Business Hours): 0% LPD

I. Media Center

1. Occupied Level: 80% LPD
2. Vacancy Level (Normal Business Hours): 50% LPD
3. Vacancy Level (Non-Business Hours): 0% LPD

J. Science Labs

1. Occupied Level: 80% LPD (Light Power Density)
2. Vacancy Level: 0% LPD

K. Programmed timed OFF

1. The system will turn off all light fixtures except for the night lights at a prescribed time designated by the Owner. However, if the system senses occupancy in the building it will override the scheduled time off until 15 minutes after building vacancy is detected through a gradual change in light levels when occupancy is no longer detected.

L. Parking Garage

1. Occupied Level: 80% LPD
2. Vacancy Level (Normal Business Hours): 50% LPD
3. Vacancy Level (Non-Business Hours): 10% LPD

2.15 CONTROLLED RECEPTACLE PROGRAMMING

A. The controlled outlets shall be programmed as follows:

1. Normal Business Hours: ON (Verify time range with the Owner)
2. Non-Business Hours: Controlled by occupancy/vacancy sensor.

2.16 EXAMINATION

A. Verify that field measurements are as shown on the drawings.

B. Verify that ratings and configurations of system components are consistent with the indicated requirements.

C. Verify that mounting surfaces are ready to receive system components.

D. Verify that conditions are satisfactory for installation prior to starting work.

2.17 INSTALLATION

A. The control system shall be installed and fully wired as shown on the plans by the installing contractor. The contractor shall complete all electrical connections to all control circuits.

B. Install the work of this Section in accordance with manufacturer's printed instructions unless otherwise indicated.

C. Provide written or computer-generated documentation on the commissioning of the system including room by room description including:

1. Sensor parameters, time delays, sensitivities and daylighting setpoints.
2. Sequence of operation, (e.g. manual ON, Auto OFF. Etc.).
3. Load parameters (e.g. blink warning, etc.).

2.18 PRODUCT SUPPORT AND SERVICE

A. Factory telephone support shall be available at no cost to the owner. Factory assistance shall consist of solving programming or application questions concerning the control equipment.

2.19 FIELD QUALITY CONTROL

A. Manufacturer's Full-Scope Start-Up Service is required.

1. Manufacturer's authorized Service Representative to conduct site visit upon completion of lighting control system installation to perform system startup and verify proper operation:
   a. Service Representative to verify sensor locations, in accordance with layout provided by Lighting Control Manufacturer; Lighting Control Manufacturer may direct Contractor regarding sensor relocation should conditions require a deviation from locations indicated.
   b. Verify connection of power wiring and load circuits.
   c. Verify connection and location of controls.
   d. Energize wireless hubs.
   e. Associate occupancy/vacancy sensors, daylight sensors, wireless remotes, and wall stations to load control devices.
   f. Provide initial rough calibration of sensors; fine-tuning of sensors is responsibility of Contractor unless provided by Lighting Control Manufacturer.
   g. Program timeclock schedules per approved sequence of operations.
   h. Configure load shed parameters per approved sequence of operations.
   i. Verify system operation control by control.
   j. Obtain sign-off on system functions.

B. Correct defective work, adjust for proper operation, and retest until entire system complies with contract documents.

2.20 COMMISSIONING

A. Comply with requirements specified in Division 01.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup checks according to the approved manufacturer's written instructions.

C. Qualifications for factory certified field service engineer:

1. Certified by the equipment manufacturer on the system installed.

D. Make first visit upon completion of installation of WaveLinx Connected Lighting system:

1. Verify locations of Wireless Area Controllers
2. Verify implementation of Construction Group process
3. Identify connected devices and program using WaveLinx Mobile and Automatic Code Commissioning.
4. Verify that system operation control based on defined Sequence of Operations (SOO).
5. Obtain sign-off on system functions.

E. Due to building operations, start-up of WaveLinx Connected Lighting system may be required outside of normal business hours (Monday through Friday, 7 a.m. to 5 p.m.).

F. For LEED projects, manufacturer shall conduct an on-site walkthrough to demonstrate system functionality to a Commissioning Agent.

G. During this visit, the manufacturer’s Field Service Engineer will perform tasks, at the request of the facility representative or Commissioning Agent, such as to demonstrate wall control functions, explain or describe occupancy and/or daylight sensor functionality.

H. On-site Walkthrough.

I. Lighting control system manufacturer to provide a factory certified Field Service Engineer to demonstrate system functionality to the Commissioning Agent.

2.21 TRAINING AND SERVICE

A. Comply with Section 260001.

B. Conduct four 4-hour training sessions. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

2.22 SPARE PARTS

A. Furnish the following component at the end of the project to the Owner:

1. Sensors: 10 for each type installed.
2. WaveLinx wall stations: 10 for each type installed.
3. Controlled receptacle: 20
4. Relay switchpack: 20 of each type installed.
5. Wireless Area Controller: 2

End of Section

Section 26 12 19

PAD-MOUNTED, LIQUID FILLED, MEDIUM-VOLATGE TRANSFORMERS

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. This specification covers the electrical and mechanical characteristics of 45-10,000 kVA Three-Phase Step-Down Pad-Mounted Distribution Transformers. KVA ratings for transformers with secondary voltages not exceeding 700V are 45-5000 kVA, while kVA ratings for transformers with secondary voltages greater than 700V are 500-12,000 kVA.

1.4 SUBMITTALS

A. Product Data: For each fuse type indicated.

B. Operation and maintenance data.

1.5 FACTORY TESTS

A. Factory Tests shall be required.

B. Factory Tests shall be in accordance with the following requirement:

1. Transformers shall be thoroughly tested at the factory to ensure that there are no electrical or mechanical defects. Tests shall be conducted as per IEEE Standards. Factory tests shall be certified. The following tests shall be performed:
   a. Perform insulation-resistance tests, winding-to-winding and each winding-to-ground.
   b. Perform turns-ratio tests at all tap positions.

1.6 APPLICABLE STANDARDS

A. All characteristics, definitions, and terminology, except as specifically covered in this specification, shall be in accordance with the latest revision of the following IEEE®, Department of Energy, and NEMA® standards.

1. IEEE Std C57.12.00™-2015 – IEEE Standard for Standard General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers
2. IEEE Std C57.12.28™ - 2014 standard – Pad-Mounted Equipment - Enclosure Integrity.
3. IEEE Std C57.12.29™ - 2014 standard - IEEE Standard for Pad-Mounted Equipment - Enclosure Integrity for Coastal Environments – applicable when stainless steel construction is specified.
4. IEEE Std C57.12.34™-2015 standard – Standard Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers (2500 kVA and Smaller) - High Voltage: 34500GrdY/19920 Volts and Below; Low-Voltage: 480 Volt 2500 kVA and Smaller (issued in March 2005 - combines IEEE Std C57.12.22 and IEEE Std C57.12.26 standards).
5. IEEE Std C57.12.90™-2010 – IEEE Standard Test Code for Liquid-Immersed Distribution, Power, and Regulating Transformers and IEEE Guide for Short-Circuit Testing of Distribution and Power Transformers
6. IEEE Std C57.12.91™-2011 standard – Guide for Loading Mineral-Oil-Immersed Transformers.
7. IEEE Std C57.154™ -2012 – IEEE Standard for the Design, Testing, and Application of Liquid-Immersed Distribution, Power, and Regulating Transformers Using High-Temperature Insulation Systems and Operating at Elevated Temperatures
8. NEMA® TR 1-1993 (R2000) – Transformers, Regulators and Reactors, Table 0-2 Audible Sound Levels
9. NEMA 260-1996 (2004) – Safety Labels for Pad-Mounted Switchgear and Transformers Sited in Public Areas.
10. 10 CFR Part 431 – Department of Energy–Energy Conservation Program: Energy Conservation Standards for Distribution Transformers; Final Rule
11. IEEE Std 386™-2016 – IEEE Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600 V

1.7 SUBMITTALS

A. Submit in accordance with the following requirements:

1. Shop Drawings:
   a. Submit sufficient information to demonstrate compliance with drawings and specifications.
   b. Include electrical ratings, nameplate data, impedance, outline drawing with dimensions and front, top, and side views, weight, mounting details, decibel rating, termination information, temperature rise, no-load and full-load losses, regulation, overcurrent protection, connection diagrams, and accessories.
   c. Complete nameplate data, including manufacturer’s name and catalog number.
   d. The following data shall be submitted with the proposal:
      1) Core losses
      2) Winding losses
      3) Percent Impedance
      4) Typical bid drawing
      5) Drawing – drawings shall show dimensions and features.

2. Manuals:
   a. When submitting the shop drawings, submit companion copies of complete maintenance and operating manuals, including technical data sheets, wiring diagrams, and information for ordering replacement parts.
      1) Identify terminals on wiring diagrams to facilitate installation, maintenance, and operation.
      2) Indicate on wiring diagrams the internal wiring for each piece of equipment and interconnections between the pieces of equipment.
      3) Approvals will be based on complete submissions of manuals, together with shop drawings.
   b. If changes have been made to the maintenance and operating manuals originally submitted, submit updated maintenance and operating manuals two weeks prior to the final inspection.
      1) Update the manual to include any information necessitated by shop drawing approval.
      2) Show all terminal identification.
      3) Include information for testing, repair, troubleshooting, assembly, disassembly, and recommended maintenance intervals.
      4) Provide a replacement parts list with current prices. Include a list of recommended spare parts, tools, and instruments for testing and maintenance purposes.

B. Certifications:

1. Two weeks prior to the final inspection, submit the following certifications.
   a. Certification by the manufacturer that the transformers conform to the requirements of the drawings and specifications.
   b. Certification by the Contractor that the transformers have been properly installed, connected, and tested.

1.8 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers

1. Eaton
2. ABB
3. Square D
4. Or approved equal

B. Basis of design product shall be by Eaton, 3000-3660 kVA 13800 Delta 480Y/277V, Temperature Rise: 55/75-degree average winding rise.

2.2 RATINGS

A. The transformer shall be designed in accordance with this specification. The kVA rating shall be as shown on the drawings.

B. The primary voltage shall be 13800 volts. The basic impulse insulation level (BIL) shall be 95 kV.

C. The secondary voltage shall be 480/277 wye. The basic insulation level (BIL) of the secondary voltage shall be 30 kV.

D. The transformer shall include full capacity high-voltage taps. The tap changer shall be clearly labeled to reflect that the transformer must be de-energized before operating the tap changer as required in Section 4.3 of IEEE Std C57.12.34™-2009 standard. The unit shall include two 2-1/2 % taps above and below rated nominal voltage.

E. The average winding temperature rise above ambient temperature, when tested at the transformer rating, shall not exceed 55 Deg. C at the base transformer rating and shall not exceed 65 Deg. C when tested at 112% of the base rating.

F. The percent impedance voltage, as measured on the rated voltage connection, shall be 5.75%. The tolerance on the impedance shall be +/- 7.5% of nominal value.

2.3 CONSTRUCTION

A. The core and coil shall be vacuum processed to ensure maximum penetration of insulating fluid into the coil insulation system. While under vacuum, the windings will be energized to heat the coils and drive out moisture, and the transformer will be filled with preheated filtered degassed insulating fluid. The core shall be manufactured from burr-free, grain-oriented silicon steel and shall be precisely stacked to eliminate gaps in the corner joints. The coil shall be insulated with B-stage, epoxy coated, diamond pattern, insulating paper, which shall be thermally cured under pressure to ensure proper bonding of conductor and paper.

B. The dielectric coolant shall be listed less-flammable fluid meeting the requirements of National Electrical Code Section 450-23 and the requirements of the National Electrical Safety Code (IEEE Std C2™-2002 standard), Section 15. The dielectric coolant shall be non-toxic*, non-bioaccumulating and be readily and completely biodegradable per EPA OPPTS 835.3100. The base fluid shall be 100% derived from edible seed oils and food grade performance enhancing additives. The fluid shall not require genetically altered seeds for its base oil. The fluid shall result in zero mortality when tested on trout fry *. The fluid shall be certified to comply with the US EPA Environmental Technology Verification (ETV) requirements and tested for compatibility with transformer components. The fluid shall be Factory Mutual Approved®, UL® Classified Dielectric Medium (UL-EOUV) and UL® Classified Transformer Fluid (UL-EOVK), Envirotemp™ FR3™ fluid.

C. Tank and Cabinet Enclosure

1. The high-voltage and low-voltage compartments, separated by a metal barrier, shall be located side-by-side on one side of the transformer tank. When viewed from the front, the low-voltage compartment shall be on the right. Each compartment shall have a door that is constructed to provide access to the high-voltage compartment only after the door to the low-voltage compartment has been opened. There shall be one or more additional fastening devices that must be removed before the high-voltage door can be opened.

Where the low-voltage compartment door is of a flat panel design, the compartment door shall have three-point latching with a handle provided for a locking device. Hinge pins and associated barrels shall be constructed of corrosion-resistant material, passivated ANSI® Type 304 or the equivalent.

2. A recessed, captive, penta-head or hex-head bolt that meets the dimensions per IEEE Std C57.12.28™-2014 standard shall secure all access doors.
3. The compartment depth shall be in accordance with IEEE Std C57.12.34™-2009 standard, unless additional depth is specified.
4. The tank base must be designed to allow skidding or rolling in any direction. Lifting provisions shall consist of four lifting lugs welded to the tank.
5. The tank shall be constructed to withstand 7 psi without permanent deformation, and 15 psi without rupture. The tank shall include a 15 psig pressure relief valve with a flow rate of minimum 35 SCFM.
6. The exterior of the unit shall be painted Munsell 7GY3.29/1.5 green (STD) in color.
7. The tank shall be complete with an anodized aluminum laser engraved nameplate. This nameplate shall meet Nameplate B per IEEE Std C57.12.00™-2010 standard.

D. High Voltage Bushings and Terminals

1. High voltage bushings will be installed in the high voltage termination compartment located on the front left of the transformer and requiring access via the low voltage termination compartment on the front right.
2. Bushing Style
   a. The high voltage bushings shall be 15/25 kV 200A bushing wells with bushing well inserts installed. The bushings shall be externally removable and be supplied with a removable stud.

3. Bushing Configuration
   a. The transformer shall be loop feed, dead front, provided with six (6) high voltage bushings.

E. Low Voltage Bushings and Terminals

1. Bushing Style
   a. The transformer shall be provided with tin-plated spade-type bushings for vertical takeoff. The spacing of the connection holes shall be 1.75” on center, per IEEE Std C57.12.34™-2009 standard Figure 13a.
   b. Transformer to have one-piece bushings.
   c. Bushing supports shall be provided for transformers requiring 10 or more connection holes. Bushing supports shall be affixed to the cabinet sidewalls; tank-mounted supports mountings are not acceptable.

2. Bushing Configuration
   a. The transformer shall be provided with bushings in a staggered arrangement in accordance with IEEE Std C57.12.34™-2009 standard.

F. Switching

1. Primary Switching: The primary switching scheme provided with the transformer shall be one under-oil four-position T-blade load-break sectionalizing switch.

G. Overcurrent Protection

1. Integral vacuum fault interrupter (VFI): (available from 13 amps up to 900 amps of full-load transformer current, up to 34.5 kV, grounded wye or delta, maximum 150 KV BIL) The high-voltage or low-voltage overcurrent protection scheme provided with the transformer shall be an integral Vacuum Fault Interrupter (VFI). The VFI shall also include a Tri-Phase electronic breaker control with over 100 minimum trip settings and five (5) selectable time current curves. The minimum trip setting shall be defined by the manufacturer amps, and curve profile shall be the EF, KF, TF, F, or H (Re: Bulletin B210-02039 and Service Information S285-75-1 for the electronic control).

H. Overvoltage Protection

1. The overvoltage protection scheme provided with the transformer shall protect the high-voltage voltage winding.
2. Dead-Front Bushings: Distribution Class M.O.V.E. Dead-front elbow arresters shall be included and installed on 200 A rated dead-front bushing interfaces.

2.4 ADDITIONAL REQUIREMENTS

A. Additional transformer rating nameplate – In addition to the standard nameplate located on the transformer tank, a second nameplate shall be included. The nameplate shall be mounted external to the termination compartments with an industrial grade double-sided adhesive. Its location shall be identified on the data sheet.

B. External drain valve with sampler – A 1.0” drain valve with sampling device shall be located outside of the cable compartment on the low voltage side of the tank. The valve shall be protected by a hinged cover with padlock provisions.

C. Devices shall include the following: liquid level gauge, dial-type thermometer, pressure/vacuum gauge, pressure relief valve.

2.5 LABELING

A. A temporary bar code label shall be attached to the exterior of the transformer in accordance with IEEE Std C57.12.34™-2009 standard.

2.6 FINISH PERFORMANCE REQUIREMENTS

A. The tank coating shall meet all requirements in IEEE Std C57.12.28™-2014 standard including:

1. Salt Spray
2. Crosshatch adhesion
3. Humidity
4. Impact
5. Oil resistance
6. Ultraviolet accelerated weathering
7. Abrasion resistance – taber abraser

B. The enclosure integrity of the tank and cabinet shall meet the requirements for tamper resistance set forth in IEEE Std C57.12.28™-2014 standard including but not limited to the pry test, pull test, and wire probe test.

2.7 PRODUCTION TESTING

A. All units shall be tested for the following:

1. No-Load (85 deg. C or 20 deg. C) losses at rated current.
2. Total (85 deg. C) losses at rated current.
3. Percent Impedance (85 deg. C) at rated current.
4. Excitation current (100% voltage) test.
5. Winding resistance measurement tests.
6. Ratio tests using all tap settings.
7. Polarity and phase relation tests.
8. Induced potential tests.
9. Full wave and reduced wave impulse test.

B. Transformers shall conform to efficiency levels for liquid immersed distribution transformers, as specified in the Department of Energy ruling “10 CFR Part 431 Energy Conservation Program: Energy Conservation Standards for Distribution Transformers; Final Rule; April 18, 2013.” Manufacturer shall comply with the intent of all regulations set forth in noted ruling.

C. In addition, the manufacturer shall provide certification upon request for all design and other tests listed in IEEE Std C57.12.00™-2010 standard, including verification that the design has passed short circuit criteria per IEEE Std C57.12.00™-2010 standard and IEEE Std C57.12.90™-2010 standard.

D. In the event of proposal bid evaluated with guaranteed losses due to a loss evaluation (see section 10.0), manufacturer shall conform to guaranteed average losses as specified in IEEE Std C57.12.00™-2010 standard. The no-load losses of a transformer shall not exceed the specified no-load losses by more than 10%, and the total losses of a transformer shall not exceed the specified total losses by more than 6%.

2.8 ACCESSORIES

A. The following accessories and options shall be provided:

1. Bolted main tank cover
2. 1.0” upper fill plug
3. 1.0” drain valve w/ sampling device in LV compartment
4. Automatic pressure relief valve
5. Metal drip shield
6. 20” deep cabinet
7. Ground provisions per IEEE Std C57.12.34™-2009 standard section 9.11.
8. Meet NEMA® TR-1 sound levels
9. Liquid level gauge
10. Dial-type thermometer gauge
11. Pressure vacuum gauge
12. Ground connectors
13. Non-PCB decal
14. UL® Listed transformer (certifying compliance with ANSI® standards only) per UL® XPLH

2.9 TRANSFORMER DETAILS

A. Eaton Catalog #: Catalog #: **00000A67XAVA** with the following features:

1. kVA: 3000-3660 kVA 3 Phase PEAK Pad-Mounted Transformer
2. Temperature Rise: 55/75 degree average winding rise
3. Cooling Class: KNAN
4. Insulating fluid: Envirotemp FR3
5. Efficiency Standard: None
6. High Voltage: 13800 Delta Volts
7. High Voltage kV Class: 15 kV Class
8. High Voltage kV BIL: 95 kV BIL
9. Primary Termination Style: Dead Front
10. Primary Feed Type: Loop Feed
11. Taps: 2 - 2.5% taps above and 2 - 2.5% taps below nominal
12. Tap Changer: 5-position tap changer
13. Tap Changer Switch Location: Frontplate HV Compartment
14. High Voltage Bushings: 200-amp Cooper bushing wells with removable studs (Qty: 6)
15. High Voltage Inserts: 15 kV, 95 kV BIL load-break inserts (Qty: 6)
16. Load-break Switching: 15-38 kV, 300A 2-Position
17. Load-break Switch Location: Frontplate HV Compartment
18. High Voltage Arresters: Varistar elbow arresters, 15 kV class, 18 kV (Qty: 3)
19. Overcurrent Protection: Vacuum Fault Interrupter (VFI)
20. VFI Mechanism: 15/25kV, 12.5kA Mechanism
21. VFI Motor: None (no motor or provisions)
22. VFI Operator Location: Frontplate/Segment 1
23. VFI Transformer Type: S-VFI (Smart-VFI)
24. VFI Control Type: EDR-3000 = Relay w/ current monitoring
25. Protective Monitoring: Current Monitoring Only
26. Visible Disconnect Type: Visible Loadbreak
27. NEMA 4X box with test switches, heater, and battery backup: Included
28. Low Voltage: 480Y/277 Volts
29. Low Voltage kV Class: 1.2 kV Class
30. Low Voltage kV BIL: 30 kV BIL
31. Secondary Termination Style: Live Front
32. Secondary Feed Type: Radial Feed
33. Low Voltage Bushing Location: LV Frontplate (seg 1)
34. Low Voltage Bushings: Integral copper 12-hole spade bushing(s) (Qty: 4)
35. Bushing Supports: Standard LV Bushing Support Assembly
36. Low Voltage Arresters: Secondary arrester, 3-phase Storm Trapper, 400 V MCOV (Qty: 1)
37. CTs Wired to Shorting Type Terminal Blocks: CT Terminal Blocks Included
38. CT Wiring: #12 AWG CT Wiring
39. Cabinet: 24-inch-deep cabinet
40. Cabinet hardware: Penta-head cabinet door bolts
41. Cabinet Types: IEEE/ANSI
42. Infrared Viewing Windows: No Window Required
43. Bushing Layout: K 4.5 Loop feed per IEEE C57.12.34-2015 Figure 11 minimum dimensions (without bails)
44. Coatings: Munsell Green - Munsell 7GY 3.29/1.5
45. Decal Options: Non-PCB Decal
46. Nameplate Options: Additional Nameplate (Outside LV Door)
47. FM / UL Certifications: UL Listed
48. Liquid Level Gauge: Liquid level gauge
49. Pressure Vacuum Gauges: Pressure/vacuum gauge
50. Thermometer: Thermometer, dial-type
51. Other Fittings: Schrader valve
52. Drain Valve: Drain valve with sampler in LV Compartment (1")

53. Fill Valve: Fill plug in LV Compartment
54. Pressure Relief Device: Pressure relief device, 50 SCFM
55. Ground Pads: Two-hole ground pads (Qty: 3)
56. Anchoring: Seismic anchoring provisions
57. Nitrogen Blanket: Nitrogen Blanket
58. Packaging: None (Pallet Not Included)
59. Cover: Welded cover with handhole
60. Gauges Location: Inside Main Cabinet on Front Plate
61. Impedance: 5.74% (For Reference Only)
62. Estimated Overall Height: 87.40 inches
63. Estimated Overall Width: 89.86 inches
64. Estimated Overall Depth: 104.30 inches
65. Primary Conductor Material: Aluminum
66. Secondary Conductor Material: Aluminum

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install transformers outdoors, as shown on the drawings, in accordance with the NEC, and as recommended by the manufacturer.

B. Anchor transformers with rustproof bolts, nuts, and washers not less than 12 mm (1/2 inch) diameter, in accordance with manufacturer's instructions, and as shown on drawings.

C. In seismic areas, transformers shall be adequately anchored and braced per details on structural contract drawings to withstand the seismic forces at the location where installed.

D. Mount transformers on concrete slab. Unless otherwise indicated, the slab shall be at least 200 mm (8 inches) thick, reinforced with a 150 by 150 mm (6 by 6 inches) No. 6 mesh placed uniformly 100 mm (4 inches) from the top of the slab. Slab shall be placed on a 150 mm (6 inches) thick, well-compacted gravel base. The top of the concrete slab shall be approximately 100 mm (4 inches) above the finished grade. Edges above grade shall have 12-1/2 mm (1/2 inch) chamfer. The slab shall be of adequate size to project at least 200 mm (8 inches) beyond the equipment. Provide conduit turnups and cable entrance space required by the equipment to be mounted. Seal voids around conduit openings in slab with water- and oil-resistant caulking or sealant. Cut off and bush conduits 75 mm (3 inches) above slab surface.

E. Grounding:

1. Ground each transformer in accordance with the requirements of the NEC. Install ground rods per the requirements of Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS, to maintain a maximum resistance of 5 ohms to ground.
2. Connect the ground rod to the ground pads in the medium- and low-voltage compartments.
3. Install and connect the cable shield grounding adapter per the manufacturer's instructions. Connect the bleeder wire of the cable shield grounding adapter to the loadbreak or deadbreak elbow grounding point with minimum No. 14 AWG wire, and connect the ground braid to the grounding system with minimum No. 6 AWG bare copper wire. Use soldered or mechanical grounding connectors listed for this purpose.

3.2 ACCEPTANCE CHECKS AND TESTS

A. Perform manufacturer's required field tests in accordance with the manufacturer's recommendations. In addition, include the following:

1. Visual Inspection and Tests:
   a. Compare equipment nameplate data with specifications and approved shop drawings.
   b. Inspect physical and mechanical condition. Check for damaged or cracked bushings and liquid leaks.
   c. Verify that control and alarm settings on temperature indicators are as specified.
   d. Inspect all field-installed bolted electrical connections, using the calibrated torque-wrench method to verify tightness of accessible bolted electrical connections, and perform thermographic survey after energization under load.
   e. Vacuum-clean transformer interior. Clean transformer enclosure exterior.
   f. Verify correct liquid level in transformer tank.
   g. Verify correct equipment grounding per the requirements of Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS.
   h. Verify the presence and connection of transformer surge arresters, if provided.
   i. Verify that the tap-changer is set at rated system voltage.

3.3 FOLLOW-UP VERIFICATION

A. Upon completion of acceptance checks, settings, and tests, the Contractor shall demonstrate that the transformers are in good operating condition and properly performing the intended function.

3.4 SPARE PARTS

A. Deliver the following spare parts for the project to the Owner two weeks prior to final inspection:

1. Six insulated protective caps.
2. One spare set of medium-voltage fuses for each size and type of fuse used in the project.

3.5 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup checks according to the approved manufacturer's written instructions.

3.6 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct two 4-hour training sessions. Train the Owner's maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

End of Section

Section 26 22 00

LOW-VOLTAGE TRANSFORMERS

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. Dry-type distribution transformers for non-linear loads single and three phase primary and secondary voltages of 600Vand less and capacity ratings of 15kVA through 1000kVA.

1.4 REFERENCE STANDARDS

A. Transformers 750kVA and smaller shall be listed by Underwriters Laboratories.

B. FEDERAL REGISTER – US Department of Energy, Office of Energy Efficiency and Renewable Energy. 10 CFR Part 430, July 29, 2004. Energy Conservation Program for Commercial and Industrial Equipment: Energy Conservation Standards for Distribution Transformers (Designated C-3).

C. ANSI/NEMA ST20 and UL 1561 - Dry Type Transformers for General Applications.

D. ANSI/NEMA TP-1 – Guide for Determining Energy Efficiency for Distribution Transformers.

E. ANSI/NEMA TP-2 – Standard Test Method for Measuring Energy Consumption of Distribution Transformers.

F. Metering Standards:

1. Computational algorithms per IEEE Std 1459-2000.
2. UL 916, UL 61010C-1 CAT III.

3. IEEE C57.110-1998 – IEEE Recommended Practice for establishing transformer capability when feeding non-sinusoidal load currents.
4. IEEE-1100 – Recommended Practice for Powering and Grounding Sensitive Electronic Equipment.
5. IEEE Standard 1100 documents how typical transformers feeding electronic equipment produce substantially higher losses under electronic equipment load compared to under linear load, requiring derating.

1.5 SUBMITTALS

A. Submit product data including the following:

1. Insulation system impregnant data sheet as published by supplier.
2. Construction Details including enclosure dimensions, kVA rating, primary & secondary nominal voltages, voltage taps, BIL, unit weight.
3. Basic Performance characteristics including insulation class, temperature rise, core and coil materials, impedances & audible noise level, unit weight.
   a. 25-year Product Warranty Certificate.
   b. Packaging method for shipment (meeting specification requirements) including representative picture.
   c. UL approval for non-linear loading greater than 5% and other applicable agency certifications.

1.6 DELIVERY, STORAGE AND HANDLING

A. Store and protect products.

B. Store in a warm, dry location with uniform temperature. Cover ventilation openings to keep out dust, water, and other foreign material.

C. Handle transformers using lifting eyes and/or brackets provided for that purpose. Protect against unfavorable external environment such as rain and snow, during handling.

1.7 COMMERCIAL PRODUCT

A. Transformer shall be a standard item in the manufacturer’s catalog.

1.8 SUMMARY

A. Dry-type distribution transformers for non-linear loads single and three phase primary and secondary voltages of 600Vand less and capacity ratings of 15kVA through 1000kVA.

1.9 REFERENCE STANDARDS

A. Transformers 750kVA and smaller shall be listed by Underwriters Laboratories.

B. FEDERAL REGISTER – US Department of Energy, Office of Energy Efficiency and Renewable Energy. 10 CFR Part 430, July 29, 2004. Energy Conservation Program for Commercial and Industrial Equipment: Energy Conservation Standards for Distribution Transformers (Designated C-3).

C. ANSI/NEMA ST20 and UL 1561 - Dry Type Transformers for General Applications.

D. ANSI/NEMA TP-1 – Guide for Determining Energy Efficiency for Distribution Transformers.

E. ANSI/NEMA TP-2 – Standard Test Method for Measuring Energy Consumption of Distribution Transformers.

F. Metering Standards:

1. Computational algorithms per IEEE Std 1459-2000.
2. UL 916, UL 61010C-1 CAT III.
3. IEEE C57.110-1998 – IEEE Recommended Practice for establishing transformer capability when feeding non-sinusoidal load currents.
4. IEEE-1100 – Recommended Practice for Powering and Grounding Sensitive Electronic Equipment.
5. IEEE Standard 1100 documents how typical transformers feeding electronic equipment produce substantially higher losses under electronic equipment load compared to under linear load, requiring derating.

1.10 SUBMITTALS

A. Submit product data including the following:

1. Insulation system impregnant data sheet as published by supplier.
2. Construction Details including enclosure dimensions, kVA rating, primary & secondary nominal voltages, voltage taps, BIL, unit weight.
3. Basic Performance characteristics including insulation class, temperature rise, core and coil materials, impedances & audible noise level, unit weight.
   a. 25-year Product Warranty Certificate.
   b. Packaging method for shipment (meeting specification requirements) including representative picture.
   c. UL approval for non-linear loading greater than 5% and other applicable agency certifications.

1.11 DELIVERY, STORAGE AND HANDLING

A. Store and protect products.

B. Store in a warm, dry location with uniform temperature. Cover ventilation openings to keep out dust, water, and other foreign material.

C. Handle transformers using lifting eyes and/or brackets provided for that purpose. Protect against unfavorable external environment such as rain and snow, during handling.

1.12 COMMERCIAL PRODUCT

A. Transformer shall be a standard item in the manufacturer's catalog.

1.13 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. ABB.
3. Square D; a brand of Schneider Electric.
4. Or approved equal.

2.2 BASIS OF DESIGN

A. The system specified is based upon products by Eaton Electrical Inc.; and represents the performance standard upon which any equivalent solution shall be based.

2.3 RATINGS INFORMATION

A. All insulating materials are to exceed NEMA ST20 standards and be rated for 220oC UL component recognized insulation system.

B. Neither the primary nor the secondary temperature shall exceed 220oC at any point in the coils while carrying their full rating of non-sinusoidal load. Transformers are to be UL listed and labeled for K-13 as defined as the sum of fundamental and harmonic Ih(pu)2h2 per UL 1561. Transformers evaluated by the UL K-Factor evaluation shall be listed for 150°C average temperature rise.

C. K-Factor rated transformers shall have an impedance range of 3% to 6%, and shall have a minimum reactance of 2% in order to help reduce neutral current when supplying loads with large amounts of third harmonic current.

D. Transformers 15kVA and larger shall have a minimum of 6 - 2.5% full capacity primary taps for 480V primaries and a minimum of 2 - 5% full capacity taps for 208V primaries. Exact voltages and taps to be as designated on the plans or the transformer schedule.

E. The maximum temperature of the top of the enclosure shall not exceed 50oC rise above a 40oC ambient.

F. The transformer(s) shall be rated as indicated in the following schedule:

1. Identification Number(s)
2. kVA Rating
3. Voltages
4. Phase
5. Frequency
6. Temperature Rise
7. K-Factor

2.4 CONSTRUCTION

A. Transformer coils shall be of the continuous wound construction and shall be impregnated with non-hygroscopic, thermosetting varnish.

B. All cores to be constructed with low hysteresis and eddy current losses. Magnetic flux densities are to be kept well below the saturation point to prevent core overheating. The core laminations shall be clamped together with steel angles. The completed core and coil shall be bolted to the base of the enclosure but isolated by means of rubber vibration-absorbing mounts. There shall be no metal-to-metal contact between the core and coil and the enclosure except for a flexible safety ground strap. Sound isolation systems requiring the complete removal of all fastening devices will not be acceptable.

C. The core of the transformer shall be visibly grounded to the enclosure by means of a flexible grounding conductor sized in accordance with applicable UL and NEC standards.

D. The transformer enclosures shall be ventilated and be fabricated of heavy gauge, sheet steel construction. The entire enclosure shall be finished utilizing a continuous process consisting of degeasing, cleaning and phosphatizing, followed by electrostatic deposition of polymer polyester powder coating and baking cycle to provide uniform coating of all edges and surfaces. The coating shall be UL recognized for outdoor use. The coating color shall be ANSI 49.

E. Transformers shall be supplied with quality, full width electrostatic shields resulting in a maximum effective coupling capacitance between primary and secondary of 33 picofarads. With transformers connected under normal, loaded operating conditions, the attenuation of line noise and transients shall equal or exceed the following limits:

1. Common Mode: 0 to 1.5kHZ - 120dB; 1.5kHZ to 10kHZ - 90dB; 10kHZ to 100kHZ - 65dB; 100kHZ to 1MHZ - 40dB.
2. Transverse Mode: 1.5kHZ to 10kHZ - 52dB; 10kHZ to 100kHZ - 30dB; 100kHZ to 1MHZ - 30dB.

2.5 SOUND LEVELS

A. Sound levels shall be warranted by the manufacturer not to exceed the following:

1. K-13 rating: 15 to 50kVA - 45dB; 51 to 150kVA - 50dB; 151 to 300kVA - 55dB; 301 to 500kVA - 60dB; 501 to 700kVA - 62dB; 701 to 1000kVA - 64dB

PART 3 - EXECUTION

3.1 INSTALLATION

A. Follow all national, state, and local codes with respect to transformer installation.

B. Where sound level may be of concern, utilize the services of a recognized and established Acoustical Consultant to provide the proper installation environment to minimize noise and vibration.

C. Check for damage and loose connections.

D. Set the transformer plumb and level.

E. Mount transformer on vibration isolation pads suitable for isolating the transformer.

F. Wall Brackets: Manufacturer's standard brackets

G. Provide Seismic restraints where required.

H. Coordinate all work in this Section with that in other sections.

I. Verify all dimensions in the field.

J. Upon completion of the installation, an infrared scan shall be provided for all bolted connections. Correct any deficiencies.

K. Adjust transformer secondary voltages to provide the required voltage at the loads.

L. Non-compliant products shall be replaced at no cost to the customer.

3.2 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup checks according to the approved manufacturer's written instructions.

3.3 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct two 4-hour training sessions. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

End of Section

Section 26 24 13

SWITCHBOARDS

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. Section Includes:

1. Service and distribution switchboards rated 600 V and less.
2. Transient voltage suppression devices.
3. Disconnecting and overcurrent protective devices.
4. Instrumentation.
5. Control power.
6. Accessory components and features.
7. Identification.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Switchboards shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.5 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: For each switchboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
2. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards.
3. Include schematic and wiring diagrams for power, signal, and control wiring.

C. Seismic Qualification Certificates: Submit certification that switchboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

D. Field quality-control reports.

E. Operation and maintenance data.

1.6 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NEMA PB 2.

C. Comply with NFPA 70.

D. Comply with UL 891.

1.7 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

C. Transient voltage suppression devices: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. ABB.
3. Square D; a brand of Schneider Electric.
4. Or approved equal.

2.2 BASIS OF DESIGN

A. The system specified is based upon products by Eaton Electrical Inc.; and represents the performance standard upon which any equivalent solution shall be based.

2.3 MANUFACTURED UNITS

A. Applicable Standards

1. The publications listed below form a part of this specification to the extent referenced. The latest revision of each publication shall be applied.
2. American National Standards Institute (ANSI) Publications:
   a. C2 National Electrical Safety Code (NESC)
   b. C12 Code for Electricity Metering
   c. C39.1 Requirements for Electrical Analog Indicating Instruments
   d. C57.12 Requirements for Instrument Transformers
   e. Z35.1 Specifications for Accident Prevention Signs
   f. Z55.1 Gray Finished for Industrial Apparatus and Equipment
3. National Electrical Manufacturers Association (NEMA) Publications:
   a. C2 National Electrical Safety Code (NESC)
   b. C12 Code for Electricity Metering
   c. C39.1 Requirements for Electrical Analog Indicating Instruments
   d. C57.12 Requirements for Instrument Transformers
   e. Z35.1 Specifications for Accident Prevention Signs
   f. Z55.1 Gray Finished for Industrial Apparatus and Equipment
4. National Electrical Manufacturers Association (NEMA) Publications:
   a. AB-1 Molded Circuit Breakers
   b. LI-1 Industrial Laminated Thermosetting Plastics
   c. PB-2 Dead-Front Distribution Switchboards
   d. LI-1 Industrial Laminated Thermosetting Plastics
   e. PB-2 Dead-Front Distribution Switchboards
   f. PB-2.1 Safe Handling, Installation, Operation and Maintenance of Switchboards
   g. 260 Safety Labels for Padmounted Switchgear and Transformers Sited in Public Areas
5. International Electrical Testing Association (NETA)
   a. ATS Acceptance Testing Specifications for Electrical Power Distribution Equipment
6. National Fire Protection Association (NFPA) Publications:
   a. 70-1987 National Electrical Code
7. Underwriters Laboratories, Inc. (UL) Publications:
   a. 467 Grounding and Bonding Equipment
   b. 489 Molded-Case Circuit Breakers and Circuit Breaker Enclosures
   c. 891 Dead-Front Switchboards

B. Quality Control

1. Design tests required for certification of conformance to ANSI, NEMA or UL requirements may be required for review by the engineer at the option of the owner. Design tests need not be performed on the actual equipment being submitted but must have been

performed on a sample or other unit representative of the specific construction techniques which are utilized.

2. The following factory tests shall be made on the secondary switchboard, although not necessarily in the order listed. All tests shall be in accordance with the latest revision NEMA PB-2 and/or UL 891:
   a. A dielectric withstand test of 1000 VDC shall be made between each phase and ground with all switching devices closed and phases not under test grounded.
   b. The grounding of instrument transformer cases or frames, as applicable, shall be checked with a low potential source.
   c. Control wire continuity and correctness shall be verified by actual electrical operation of the control component or individual circuit continuity checks with electrical instruments.
   d. Control wire insulation shall be tested with the application of 1000 VDC after circuit grounds have been disconnected for the test. Sensitive or electronic equipment shall be disconnected for the test.
   e. Polarity tests shall be performed to verify that instrument transformers have been correctly connected.
   f. Results of the above tests shall be submitted with final drawings in the form of certified test reports. Third party certification is not required.

C. Submittals for Approval

1. Manufacturers Data: Submit manufacturers data for the following components:
   a. Low Voltage Circuit Breaker
   b. Instruments and Meters
   c. Instrument Transformers
   d. Control Component Devices

2. Shop Drawings: Submit shop drawings for the secondary unit substation including the following:
   a. Overall dimensions, front view, sectional views, conduit entrance location(s), equipment access requirements and weights.
   b. Bus arrangements including dimensions and ampere ratings of all bus bars, including ground bus.
   c. Type and spacing of bus supports.
   d. Maximum short circuit bracing.
   e. Circuit breaker type, interrupting rating, instrument transformers and meters.
   f. Elementary diagrams and wiring diagrams having their terminals identified and indicating the internal wiring for each item of equipment and the interconnection between the items.
   g. One-line diagram.
   h. Details of bus connections.
   i. Anchoring instructions to meet UBC Seismic requirements.
   j. Instrument transformers and meters.
   k. Proposed nameplate schedule.
   l. Itemized and coded bill of material.
   m. Before shipment, all shop drawings shall be approved by the Engineer. Shipping splits shall be approved in writing.

3. Certified tests reports: Submit certified tests reports for the following:

a. Switchgear Factory Tests
b. Paint qualification test in accordance with ANSI C37.20.3 section 5.2.8
c. Before shipment all certified test reports shall be approved by the Engineer.

4. Operating and Maintenance Instructions: Furnish 3 copies of maintenance, instructional literature and renewal parts data bound in a loose-leaf notebook. Notebook shall contain but not be limited to the following:
   a. Instruments and Meters
   b. Instrument Transformers
   c. Control Component Devices
   d. Meters (each type)
   e. Circuit Breakers

D. Description

1. Furnish a dead front type, completely metal enclosed, self-supporting structure independent of wall supports. Voltage rating shall be 480Y/277 volts, 3 phase, 4 wire. It shall consist of the required number of vertical sections bolted together to form one rigid switchboard. The sides shall be covered with removable bolt-on plates. All edges of front cover panels shall be formed. Sheet steel shall be 12-gauge minimum thickness unless proof of conformance to UL 891 rigidity requirements can be submitted. Identify any sheet components constructed of less than 12-gauge steel.
2. Equipment shall comply with the latest applicable standards of NEMA PB2 and UL 891, and shall comply with all NEC and UL requirements for service entrance and a UL service entrance label shall be provided. Los Angeles City Test Lab Certification is acceptable in lieu of UL labeling.

E. Construction

1. Switchboard shall be provided with adequate lifting means and shall be capable of being rolled or moved into installation position and bolted directly to the floor without the use of floor sills.
2. All power connections shall be bused from incoming to outgoing line terminals. Use of cable is not allowed. All bus bars shall be copper with silver-plated copper bolted connections at joints. The bus bars shall be of sufficient size to limit the temperature rise to 65°C rise at the ampere rating indicated on the drawing based on UL tests, and rated to withstand thermal stresses and mechanical forces exerted during short circuit conditions when directly connected to a power source having an available fault current of 65,000 amperes symmetrical at rated voltages. Provide full capacity neutral.
3. A ground bus shall be furnished firmly secured to each vertical section structure and shall extend the entire length of the switchboard. The neutral bus shall be grounded to the ground bus with a bus conductor sized per UL and NEC requirements. An incoming ground lug shall be furnished. One ground lug for each feeder circuit shall also be supplied.
4. All hardware used at bolted connections shall be of high strength, hex head, grade 5 steel with Bellville type spring washers. All bolts and washers shall be plated. Slotted head screws are not allowed.
5. All hardware used on conductors shall be high-tensile strength and plated. All terminals shall be compression type suitable for copper cable of sizes indicated for 75°C cable.
6. The manufacturer shall supply, upon request, test results to confirm that the switchgear has been tested to substantiate designs according to applicable NEMA and UL

Standards. The tests shall verify the performance of the short circuit bracing and temperature rise of the bus assembly, the suitability of the enclosure venting and rigidity. In addition, each switchgear assembly shall be factory tested in accordance with the latest revision of NEMA PB-2 and/or UL 891.

7. Small wiring, necessary fuse blocks and terminal blocks within the switchboard shall be furnished as required. All groups of control wires shall be labeled with wire markers and all wires leaving the switchboard shall be provided with terminal blocks having suitable numbering strips. All control devices shall be provided with engraved plastic nameplates black with white core, attached with two screws.
8. Front Accessible Switchboard:
   a. All vertical sections without uniform depths shall align front and rear as shown on the drawings.
   b. All internal devices shall be removable from the front and shall be panel mounted with the necessary line and load connections front accessible. All bus connections shall be accessible from the front. Nuts shall face top or front as applicable to allow access for torquing.
   c. Mount devices so manufacturer type, catalog number, ampere rating and interrupting rating are visible without removing panels or covers.
   d. Provide padlocking provisions for each circuit breaker.

F. Overcurrent Devices

1. Incoming Main Device Section
   a. Main Circuit Breaker: Individually mounted 100% rated and shall be of full LSIG type with mechanical restraint on a common pan or rail assembly.
   b. The interior shall have three flat bus bars stacked and aligned vertically with glass reinforced polyester insulators laminated between phases. The molded polyester insulators shall support and provide phase isolation to the entire length of bus.
   c. Circuit breaker equipped with line terminal jaws shall not require additional external mounting hardware. Circuit breaker shall be held in mounted position by a self-contained bracket secured to the mounting pan by fasteners. Circuit breaker of different frame sizes shall be capable of being mounted across from each other.
   d. Line-side circuit breaker connections are to be jaw type.
   e. All unused spaces provided, unless otherwise specified, shall be fully equipped for future devices, including all appropriate connectors and mounting hardware.
   f. Electronic trip molded case circuit breakers:
      1) Electronic circuit breakers shall have the following time/current response adjustments: Long Time Pickup, Long Time Delay, Short Time Pickup, Short Time Delay, and Instantaneous settings. Each adjustment shall have discrete settings (fully adjustable) and shall be independent of all other adjustments.
      2) Circuit breaker trip system shall be a microprocessor-based true rms sensing designed with sensing accuracy through the thirteenth (13th) harmonic. Sensor ampere ratings shall be as indicated on the drawing.
      3) Local visual trip indication for overload, short circuit and ground fault trip occurrences.
      4) Long Time Pickup indication to signal when loading approaches or exceeds the adjustable ampere rating of the circuit breaker shall be provided.
      5) Communications capabilities for remote monitoring of circuit breaker trip system, to include phase and ground fault currents, pre-trip alarm indication, switch settings, and trip history information shall be provided.
      6) Circuit breaker shall be provided with Zone selective Interlocking (ZSI) communications capabilities on the short-time and ground fault functions

compatible with all other electronic trip circuit breakers and external ground fault sensing systems as noted on drawings.

7) Furnish thermal magnetic molded case circuit breakers for 250A frames and below.

2. Distribution Section Devices
   a. Circuit breaker(s) shall be group mounted with mechanical restraint on a common pan or rail assembly.
   b. The interior shall have three flat bus bars stacked and aligned vertically with glass reinforced polyester insulators laminated between phases. The molded polyester insulators shall support and provide phase isolation to the entire length of bus.
   c. Circuit breaker(s) equipped with line terminal jaws shall not require additional external mounting hardware. Circuit breaker(s) shall be held in mounted position by a self-contained bracket secured to the mounting pan by fasteners. Circuit breaker(s) of different frame sizes shall be capable of being mounted across from each other.
   d. Line-side circuit breaker connections are to be jaw type.
   e. All unused spaces provided, unless otherwise specified, shall be fully equipped for future devices, including all appropriate connectors and mounting hardware.
   f. Thermal magnetic molded case circuit breakers:
      1) Molded case circuit breakers shall have integral thermal and instantaneous magnetic trip in each pole.
      2) Circuit protective devices shall molded case circuit breakers. Circuit breakers shall be high interrupting Ampere ratings shall be as shown on the drawings.
      3) Manufacturer shall submit one set of published Ip and Iat let-through curves (as required by UL) to the owner.

3. Circuit breakers shall be operated by a toggle-type handle and shall have a quick-make, quick-break over-center switching mechanism tripping of the breaker shall be clearly indicated by handle position. Contacts shall be non-welding silver alloy and arc extinction shall be accomplished by means of arc chutes.
4. Circuit breakers in the switchboard shall be Standard Micrologic (LSI 310+/210+ Trip Units) with solid-state trip unit and flux transfer shunt trip. Breakers shall have trip rating plugs with ratings as indicated on the drawings Rating plugs shall be interlocked so they are NOT interchangeable between frames and interlocked such that a breaker cannot be latched with the rating plug removed.
5. Circuit breakers feeding motor loads shall have a high instantaneous range.
6. Trip unit shall have adjustable short time setting with a fixed instantaneous override for circuit protection. Main breakers shall be provided with additional short delay trip time adjustment for increased system coordination.
7. Breakers shall have built-in test points for testing long delay, and instantaneous functions of the breaker by means of a 120-volt operated test kit.
8. All circuit breakers rated 400A and larger in the switchboard shall be UL listed and labeled for 100% application per NEC.
9. All circuit breakers shall be provided with an Arc Flash Reduction Maintenance System for accelerated instantaneous trip to reduce arc flash. Provide:
   a. Zone-selective interlocking – 310+/210+Trip Units
   b. Energy-reducing maintenance switching with local status indicator – Arcflash Reduction Maintenance Switch (ARMS).
   c. An instantaneous trip setting that is less than the available arcing current – 310+/210+ Trip Units.
   d. An instantaneous override that is less than the available arcing current.

10. Provide Ground Fault Protection (GFP) type circuit breakers for circuit breakers rated 1000A and above in a 480/277V system.

G. Accessory Components and Features

1. Portable Test Set: For testing functions of solid-state trip devices without removing from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.

H. Identification

1. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

I. Nameplates and Signs

1. Provide all safety and warning signs in accordance with ANSI Z35.1 and as required by the NEC, NESC and any local codes.
2. Furnish Master Nameplate giving voltage, ampere rating, short circuit rating, manufacturer's name, general order number and item number.
3. An engraved lamicoid nameplate shall be provided to identify all switches, transformers, circuit breakers, instruments, door mounted devices and control equipment. Construct nameplate of 1/16 inch engraving lamicoid with letters machine engraved through black facing to white opaque core unless otherwise indicated. All nameplates shall have a 1/64-inch bevel on front edges. Nameplates shall be fastened with a minimum of two (2) stainless steel screws, not adhesive. Letter size shall be 1/4-inch high for unit identification and 1/8-inch high for device identification unless otherwise indicated.
4. Provide mimic bus manufactured of anodized red aluminum, 1/4-inch wide, fastened with flat head recessed stainless steel screws on 4 inch centers.

J. Instrumentation

1. Instrument Transformers: IEEE C57.13, NEMA EI 21.1, and the following:
   a. Current Transformers: IEEE C57.13; 5 A, 60 Hz, secondary and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.
   b. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.
   c. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker, ground-fault protection.

K. Control Power

1. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer.
2. Electrically Interlocked Main and Tie Circuit Breakers: Two control-power transformers in separate compartments, with interlocking relays, connected to the primary side of each control-power transformer at the line side of the associated main circuit breaker. 120-V secondary’s connected through automatic transfer relays to ensure a fail-safe automatic transfer scheme.

3. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.
4. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2.4 SURGE PROTECTION DEVICES (SPD)

A. Provide Type 1 surge protection device at the switchboard.

B. Surge Protection Device Description: IEEE C62.41.1 – 2002, IEEE C62.41.2 – 2002, UL 1449 Third Edition, or most recent edition & NEC Article 285 compliant and test devices according to IEEE C62.45 - 2002, Type 1, integrally mounted, solid-state, parallel-connected, with sine-wave tracking suppression and filtering modules, UL labeled with 200 kA short-circuit current rating (SCCR), and with the following features and accessories:

1. LED indicator lights for power and protection status.
2. Audible alarm, with silencing switch, to indicate when protection has failed.
3. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of system operation. Contacts shall reverse position on failure of any surge diversion module or on opening of any current-limiting device.
4. Transient-event counter set to totalize transient surges.

C. Peak Single-Impulse Surge Current Rating: 150 kA per mode/300 kA per phase.

D. Withstand Capabilities: 5000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.

E. Protection modes and UL 1449, Third Edition or most recent edition, VPR (Voltage Protection Mode) for grounded wye circuits with 480Y/277-V, three-phase, four-wire circuits shall be as follows:

1. Line to Neutral: 1200 V for 480Y/277.
2. Line to Ground: 1200 V for 480Y/277.
3. Neutral to Ground: 1200 V for 480Y/277.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Receive, inspect, handle, store and install switchboards and accessories according to NEMA PB 2.1.

B. Equipment Mounting: Install switchboards on concrete base, 4-inch (100-mm) nominal thickness. Comply with requirements for concrete base specified in Division 03 Section "Cast-in-Place Concrete".

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.

3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to switchboards.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.

D. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

E. Install filler plates in unused spaces of panel-mounted sections.

F. Install overcurrent protective devices, transient voltage suppression devices, and instrumentation.

1. Set field-adjustable switches and circuit-breaker trip ranges.

G. Install spare-fuse cabinet.

H. Comply with NECA 1.

I. Comply with requirements for terminating feeder bus specified in Division 26 Section "Enclosed Bus Assemblies." Drawings indicate general arrangement of bus, fittings, and specialties.

J. Comply with requirements for terminating cable trays specified in Division 26 Section "Cable Trays for Electrical Systems." Drawings indicate general arrangement of cable trays, fittings, and specialties.

3.2 INFRARED SCAN

A. After cleaning and inspecting switchboards and components, perform an infrared scan in accordance with switchboard and test equipment manufacturer recommendations. With the switchboard de-energized, remove accessible covers, plates, weathershields, etc. Provide supplemental barriers and safety precautions during infrared scan to prevent accidental contact with exposed energized components. Personnel working on or near energized switchboards should follow the safe work practices described in NFPA 70E, including the use of personal protective equipment (PPE) appropriate for the task being performed.

B. Energize the switchboard and turn on all normal loads supplied by the switchboard. Perform an infrared scan of all switchboard electrical connections and terminals while energized and operating under normal load conditions.

C. Use an infrared scanning device designed to measure actual operating temperatures or designed to detect significant deviations from surrounding conditions. Provide documentation of device calibration.

D. Prepare a certified report identifying the switchboard tested and describing the results of the infrared scan. Include notations of deficiencies detected, remedial actions taken, and results from retesting after remedial actions.

E. Consult switchboard manufacturer for repair or replacement recommendations if infrared scan results indicate overheating of components.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Acceptance Testing Preparation:

1. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

B. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
3. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

C. Switchboard will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup checks according to the approved manufacturer's written instructions.

3.6 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct two 4-hour training sessions. Train the Owner's maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

End of Section

Section 26 24 16

PANELBOARDS

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. Section includes distribution panelboards and lighting and appliance branch-circuit panelboards.

1.4 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Panelboards shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.

1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.5 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types and details for types other than NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Short-circuit current rating of panelboards and overcurrent protective devices.
5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
6. Include wiring diagrams for power, signal, and control wiring.

7. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards.

C. Seismic Qualification Certificates: Submit certification that panelboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

D. Field quality-control reports.

E. Panelboard schedules for installation in panelboards.

F. Operation and maintenance data.

1.6 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

B. Comply with NEMA PB 1.

C. Comply with NFPA 70.

1.7 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

C. Transient voltage suppression devices: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. ABB.
3. Square D; a brand of Schneider Electric.
4. Or approved equal.

2.2 BASIS OF DESIGN

A. The system specified is based upon products by Eaton Electrical Inc.; and represents the performance standard upon which any equivalent solution shall be based.

2.3 GENERAL REQUIREMENTS FOR PANELBOARDS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

B. Enclosures: Flush- and surface-mounted cabinets.

1. Rated for environmental conditions at installed location.
   a. Indoor Dry and Clean Locations: NEMA 250, Type 1
   b. Outdoor Locations: NEMA 250, Type 3R.
   c. Kitchen/Wash-Down Areas: NEMA 250, Type 4X, stainless steel.
   d. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

2. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box.
3. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.

4. Directory Card: Inside panelboard door, mounted in transparent card holder.

C. Incoming Mains Location: Top and bottom.

D. Phase, Neutral, and Ground Buses: Hard-drawn copper, 98 percent conductivity.

E. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Main and Neutral Lugs: Mechanical type.

3. Ground Lugs and Bus Configured Terminators: Mechanical type.

4. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.

5. Sub feed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.

F. Service Equipment Label: NRTL labeled for use as service equipment for panelboards with one or more main service disconnecting and overcurrent protective devices.

G. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.

H. Panelboard Short-Circuit Current Rating: Fully rated for the available fault current.

1. Series rating shall not be acceptable.

I. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.4 DISTRIBUTION PANELBOARDS

A. Panelboards: NEMA PB 1, power and feeder distribution type.

B. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

C. Mains: Main circuit breakers in the distribution panelboards shall be Standard Micrologic (LSI Trip Units) with solid-state trip unit and flux transfer shunt trip. Breakers shall have trip rating plugs with ratings as indicated on the drawings Rating plugs shall be interlocked so they are NOT interchangeable between frames and interlocked such that a breaker cannot be latched with the rating plug removed.

D. Branch Overcurrent Protective Devices: For Circuit-Breaker Frame Sizes 125 A and Smaller: Standard Micrologic (LSI Trip Units) with solid-state trip unit and flux transfer shunt trip. Breakers shall have trip rating plugs with ratings as indicated on the drawings Rating plugs shall be interlocked so they are NOT interchangeable between frames and interlocked such that a breaker cannot be latched with the rating plug removed. (Add #7)

E. Branch Overcurrent Protective Devices: For Circuit-Breaker Frame Sizes Larger Than 125 A: Standard Micrologic (LSI Trip Units) with solid-state trip unit and flux transfer shunt trip. Breakers shall have trip rating plugs with ratings as indicated on the drawings Rating plugs shall be interlocked so they are NOT interchangeable between frames and interlocked such that a breaker cannot be latched with the rating plug removed. (Add #7)

2.5 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

A. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.

B. Mains: Main circuit breakers in the lighting and appliance branch-circuit panelboards shall be Standard Micrologic (LSI Trip Units) with solid-state trip unit and flux transfer shunt trip. Breakers shall have trip rating plugs with ratings as indicated on the drawings Rating plugs shall be interlocked so they are NOT interchangeable between frames and interlocked such that a breaker cannot be latched with the rating plug removed.

C. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

D. Provide UL listed non-linear rated panels with 200% neutral bus bars and lugs for all 120/208-volt panelboards where fed from K rated transformers. Bus bar taps for panels with single pole branches shall be arranged for sequence phasing of the branch circuit devices. Bussing shall be braced throughout to conform to industry standard practice governing short circuit stresses in panelboards. Phase bussing shall be full height without reduction.

E. When called for, supply Surge Protective Device (SPD) units in accordance with SPD specification section here within.

F. Contactors in Main Bus: NEMA ICS 2, Class A, electrically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.

G. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

H. Column-Type Panelboards: Narrow gutter extension, with cover, to overhead junction box equipped with ground and neutral terminal buses.

2.6 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:
   a. Instantaneous trip.
   b. Long- and short-time pickup levels.
   c. Long- and short-time time adjustments.
   d. Ground-fault pickup level, time delay, and I^2t response.
4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
5. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
6. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
7. Arc-Fault Circuit Interrupter (AFCI) Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
8. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
   a. Standard frame sizes, trip ratings, and number of poles.
   b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor materials.
   c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
   d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
   e. Communication Capability: Universal-mounted communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring and Control."
   f. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.
   g. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

2.7 ACCESSORY COMPONENTS AND FEATURES

A. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

2.8 FUSIBLE BRANCH CIRCUIT PANELBOARDS (FBCP)

A. Summary

1. Furnish and install fusible branch circuit panelboards for the life safety branch of the emergency electrical system.

B. System Description

1. The panelboards shall be UL and cULus Listed.
2. Selective Coordination: Panelboards overcurrent protective devices shall be selectively coordinated with all supply side (fed from both the normal and emergency source) Eaton's Bussmann series Low-Peak™ LPJ_SP, TCF_, LPN-RK_SP/LPS-RK_SP or KRP-C_SP fuses sized at a minimum amp ratio of 2:1.

C. Basis of Design

1. Fusible Panelboards shall be Eaton's Bussmann series Quik-Spec™ Coordination Panelboards type QSCP.

D. Panelboard Ratings

1. Panelboards shall be UL Listed with a labeled short-circuit current rating equal to or greater than that indicated on the associated schedules or drawings.
2. Panelboards shall be rated 600Vac/125Vdc but marked for actual system voltage.
3. Provide Main lug only, main fused switch or main non-fused switch as indicated in the associated schedules or drawings.
4. Provide branch circuits as indicated in the associated schedules or drawings.
5. Branch circuits must be interchangeable with fusible switches from 15A to 100A without additional required space.
6. Panelboard branch circuits shall incorporate overcurrent protection and branch-circuit rated disconnecting means into a single integrated component (1 pole, 2 pole or 3 pole) that prevents removal of the fuse while energized, provides open fuse indication, and fuse ampere rating rejection feature at 15A, 20A, 30A, 40A, 50A, 60A, 70A, 90A, and 100A. Provide open fuse indication on the branch circuit fuses where indicated in the associated schedules or drawings.
7. Provide Time-Delay Indicating Fast-Acting Class CF fuses for branch circuits.
8. Bus bars shall be tin-plated copper.
9. Neutral and equipment ground bar (isolated or non-isolated) shall be provided where indicated in the associated schedules or drawings.
10. Panelboard trim shall be door-in-door type.
11. Panelboard enclosure shall be of type indicated in the associated schedules or drawings.
12. Boxes shall be a nominal 20 inches wide and 5-¾ inches deep
13. Panelboard shall be equipped with a spare branch circuit fuse holder and spare fuses (10% of fuse for each ampacity installed in branch circuits).
14. Panelboard shall be equipped with an integral Surge Protective Device, compliant with UL 1449 4th Edition. SPD shall include remote signaling contact.

E. Construction

1. Panelboard circuits 100A and less shall incorporate overcurrent protection and branch-circuit rated disconnecting means into a single integrated component.
2. Interiors shall be factory assembled.
3. Panelboard shall be equipped with a six-space spare fuse compartment for storing replacement branch circuit fuses. Spare fuse compartment shall be located behind locking panel door.
4. Bus bars shall be tin-plated copper with sufficient cross-sectional area to meet UL 67 temperature rise requirements.

5. 200A/400A rated neutrals shall be standard, 400A or 800A rated neutral shall be provided where indicated in the associated schedules or drawings.
6. Bonded neutral shall be provided where specified in associated drawings.
7. Isolated or non-isolated equipment ground bar shall be provided as indicated in the associated schedules or drawings.
8. Where a service-entrance rated panelboard is indicated in associated schedules or drawings, a bonded neutral and non-isolated equipment ground bar shall be provided by the manufacturer.
9. Main lug conductor terminations:
   a. MLO terminations shall be rated for 60/75°C, Cu-Al
   b. Main disconnect terminations shall be rated for 75°C, Cu Only
10. NEMA 1 panelboards shall be field convertible for top or bottom incoming feed. NEMA 3R panelboards are bottom feed only.

F. Main Disconnect

1. Permanently installed lockout means shall be provided on the main disconnect for lockout tagout procedures.
2. Main disconnect shall be quick-make, quick-break type.

G. Branch Fused Disconnects

1. Device shall have visible circuit ON/OFF indication with colored and international symbol markings.
2. Device shall provide open fuse indication via permanently installed indicating light.
3. Device shall be UL and cUL Listed 600Vac/200kA or 125Vdc/100kA voltage/short-circuit current rating, load-break disconnect with amp ratings and number of poles as indicated on the panelboard schedule.
4. Fuse and disconnect assembly shall be a finger-safe component with trim installed.
5. Fuse and disconnect shall be mechanically interlocked so as not to allow fuse removal while fuse terminals are energized.
6. No special tools shall be required for fuse removal.
7. Devices shall have bolt-on style bus connectors.
8. Device housing shall be clearly marked with device amperage.
9. Permanently installed lockout means shall be provided on the device for lockout tagout procedures. Permanently installed means for locking device in the ON position shall also be available.
10. Device shall provide fuse amp rating rejection at the following ampacities to ensure continued circuit protection at the specified circuit rating: 15A, 20A, 30A, 40A, 50A, 60A, 70A, 90A & 100A.

H. Main & Branch Overcurrent Protection

1. All overcurrent protective devices shall have a minimum UL Listed interrupting rating of 300kA and CSA Certified interrupting rating of 200kA.
2. Branch circuit overcurrent protection shall be 600Vac UL Listed minimum 300kA IR and CSA Certified minimum 200kA IR finger-safe fuse with Class CF (equivalent to Class J) performance characteristics.
3. Main overcurrent protective devices shall be 600Vac UL Listed minimum 300kA IR and CSA Certified minimum 200kA IR Class J fuses or Class CF (equivalent to Class J) performance fuses.
4. Where panelboard main fuses are installed, fuses in panelboard branch circuits shall selectively coordinate with main fuses for all overcurrents up to 200kA.

I. Enclosure

1. NEMA 1 enclosures shall be surface or flush mount as indicated in associated schedules or drawings. NEMA 3R enclosures shall be surface mount only.
2. Boxes shall be a nominal 20 inches wide and 5-¾ inches deep (NEMA 1) or 6.3” (NEMA 3R) with wire bending space per the National Electrical Code®.
3. Panelboard trim shall be supplied with lockable door covering all disconnect handles.
4. Panelboard trim shall be dead-front construction covering all energized parts.
5. Enclosures shall be NEMA Type 1 or Type 3R as indicated in associated schedules or drawings.
6. Door-in-door type trim shall be provided for NEMA 1 enclosures where it is specified in the associated schedules or drawings.
7. Front trim shall be lockable. All lock assemblies shall be keyed alike with like NEMA rated enclosures.

J. Integral Surge Protection

1. Panelboard should include an integral UL 1449 4th Edition Recognized Type 2 Component Assembly. Device should be certified by UL to a 20kA nominal rating. Device should also be CSA Accepted.
2. SPD status monitoring shall be provided by local visual indication and, if needed, by remote contact signaling using an optional Form C contact relay.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Receive, inspect, handle, store and install panelboards and accessories according to NEMA PB 1.1.

B. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

C. Mount top of trim 90 inches (2286 mm) above finished floor unless otherwise indicated.

D. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.

E. Install overcurrent protective devices and controllers not already factory installed.

1. Set field-adjustable, circuit-breaker trip ranges.

F. Install filler plates in unused spaces.

G. Stub four 1-inch (27-GRC) empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch (27-GRC) empty conduits into raised floor space or below slab not on grade.

H. Arrange conductors in gutters into groups and bundle and wrap with wire ties.

I. Comply with NECA 1.

3.2 INFRARED SCAN

A. After cleaning and inspecting panelboards and components, perform an infrared scan in accordance with panelboard and test equipment manufacturer recommendations. With the panelboard de-energized, remove accessible covers, plates, weathershields, etc. Provide supplemental barriers and safety precautions during infrared scan to prevent accidental contact with exposed energized components. Personnel working on or near energized panelboards should follow the safe work practices described in NFPA 70E, including the use of personal protective equipment (PPE) appropriate for the task being performed.

B. Energize the panelboard and turn on all normal loads supplied by the panelboard. Perform an infrared scan of all panelboard electrical connections and terminals while energized and operating under normal load conditions.

C. Use an infrared scanning device designed to measure actual operating temperatures or designed to detect significant deviations from surrounding conditions. Provide documentation of device calibration.

D. Prepare a certified report identifying the panelboard tested and describing the results of the infrared scan. Include notations of deficiencies detected, remedial actions taken, and results from retesting after remedial actions.

E. Consult panelboard manufacturer for repair or replacement recommendations if infrared scan results indicate overheating of components.

3.3 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 26 Section "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads and incorporating Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Acceptance Testing Preparation:

1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
2. Test continuity of each circuit.

C. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

D. Panelboards will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup checks according to the approved manufacturer's written instructions.

3.6 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct four 4-hour training sessions. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

End of Section

Section 26 24 19

MOTOR CONTROLS

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. This Section specifies furnishing and installing individually mounted motor starters and motor starters provided as components of equipment specified under other sections of these specifications. This section includes ac motor-control devices rated 600 V and less that are supplied as enclosed units.

1.4 SUBMITTALS

A. Product Data: For products specified in this Section. Include dimensions, ratings, and data on features and components.

1. Spare Parts: Include name, address, and telephone number of in-state supplier of spare parts. No out-of-state suppliers shall be permitted.

B. Shop Drawings: For motor controllers in accordance with NEMA Standards ICS for Class II, Type “B” construction, including interconnection wiring diagrams.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain similar motor-control devices through one source from a single manufacturer in accordance with Form 816 Article 1.20-1.06.01.

B. Comply with NFPA 70, NEMA ICS, AB1.

C. Listing and Labeling: Provide motor controllers specified in this Section that are listed and labeled.

1. The Terms "Listed" and "Labeled": As defined in the NEC, Article 100. Items to be UL listed and labeled: motor starters, combination motor starters, and motor circuit protectors.

1.6 COORDINATION

A. Coordinate features of controllers and accessory devices with pilot devices and control circuits to which they connect.

B. Coordinate features, accessories, and functions of each motor controller with the ratings and characteristics of the supply circuit, the motor, the required control sequence, and the duty cycle of the motor and load.

C. Coordinate motor starters and combination motor starters with the provider or mechanical equipment. Some mechanical equipment is already supplied with starters and combination motor starters by the manufacturer.

1.7 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Available Manufacturers

1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
2. ABB.
3. Square D; a brand of Schneider Electric.
4. Or approved equal.

2.2 BASIS OF DESIGN

A. The system specified is based upon products by Eaton Electrical Inc.; and represents the performance standard upon which any equivalent solution shall be based.

2.3 GENERAL

A. The Electrical Trade Contractor shall furnish and install motor starters for all motors, unless clearly indicated otherwise on the contract documents. Three phase motors shall be provided with a combination magnetic motors starter with ambient compensated overload heaters in each ground leg.

B. Construct all products of the same type, size, rating and functional characteristics to be interchangeable and identically wired (sequence wiring).

C. Nameplates:

1. Provide a nameplate on each motor starter in accordance with NEMA ICS showing manufacturer's name and brand designation, reference standard, type class and rating as applicable.
2. In addition, provide nameplate indication the starter's designation as shown on the contract drawings. Nameplates shall be 1 inch wide with ½ inch letters, constructed of three ply laminated phenolic material, engraved through black face to white core and attached with stainless steel rivets or screws. Legend shall be furnished for approval prior to engraving.

2.4 MANUAL MOTOR CONTROLLERS

A. Provide quick-make, quick-break, toggle switch type, with thermal alloy type overload protection. Use manual motor starters for single-phase motors rated less than 1/2 horsepower.

B. Toggle Switch Operator: Provide operator guarded and equipped with a red indicating light to show when the switch is in the closed position.

C. Designated units shall include "Hand-Off-Auto" selector switch and pilot light in a single enclosure (all starter selector switches shall be key operated except for in the Electrical room and Mechanical room).

D. All "Hand-Off-Auto" controls in the bays shall be key-operated.

2.5 MAGNETIC MOTOR CONTROLLERS

A. Combination Magnetic Controller: Full voltage, across-the-line, magnetic starter with motor circuit protector, sized to conform with standard NEMA ratings for the associated motor, for use on nominal 208 volt, three-phase, 60 Hertz service with control transformer for 120 volt control, three thermal type ambient compensated manual reset overload relays selected on basis of actual motor nameplate current, one convertible auxiliary interlock contacts in addition to units required for indicated control functions, cover mounted control devices (red and green pilot lights, start-stop pushbutton, and "Hand-Off-Auto" selector switch).

2.6 ENCLOSURES

A. Description: Select flush or surface-mounted enclosures suitable for the environment in which they are to be used.

B. Enclosures: Select motor controller and switch enclosures suitable for the environment in which they are to be used as follows:

1. Enclosures for use indoors and in dry, dust free areas: NEMA Type1.
2. Enclosures for outdoor locations or where moisture is present: Stainless steel NEMA Type 4X, weatherproof enclosure, as indicated.
3. Enclosures for areas where dust and dirt likely to be present: NEMA 12 industrial type.
4. Enclosures for hazardous areas: Approved for specific hazardous location.
5. Factory Finish: Degrease and provide phosphate coating, after fabrication, to surfaces which are to be painted. Apply undercoat of rust-resistant paint such as zinc chromate over the phosphate coating (except for stainless steel). Apply finish painting of baked on, ANSI 61 baked enamel.

2.7 ACCESSORIES

A. Accessories: Provide special tools or other devices normally furnished or required for installation, care and maintenance of equipment.

2.8 VARIABLE FREQUENCY DRIVE (VFD)

A. The VFDs (also known as variable frequency control (VFC)) shall be furnished under Division 23; and shall be installed and wired by the Electrical Trade Contractor.

B. All VFD shall include a disconnect switch that is pad-lockable in the open position.

C. For VFD that are in sight from the motor, no separate disconnect is required between it and the motor if equipped with a disconnect switch that is pad-lockable in the open position.

D. For VFD that are not in sight from the motor, provide a separate disconnect ahead of the VFD and the motor. “In sight from the motor” is defined by the National Electrical Code as being visible from and not more than 50 feet from.

E. When a separate motor disconnect switch is provided the disconnect switch shall include automatic “early break” auxiliary contacts that deactivate the VFD whenever the motor disconnect switch is opened. The wiring associated with the early break contacts may be run in the same conduit as the power wiring to the disconnect switch. Assure the electrical drawings indicate the required early break contact wiring. When a common VFD serves multiple direct-drive fan array motors, early break auxiliary contacts are not required.

F. Control wiring shall be as provided by the manufacturer except as modified by the approval and submittal process. Interface all local and remote devices into the control wiring and operational systems for each load as specified on the drawings.

G. Manufacturer's Representative

1. Provide the services of a qualified factory-trained manufacturer's representative to assist the Contractor in installation and start-up of the equipment specified. The manufacturer's representative shall provide technical direction and assistance to the Electrical Trade Contractor in verification of general assembly of the equipment, connections and adjustments, and testing of the assembly and components contained therein.
2. The following minimum work shall be performed under the technical direction of the manufacturer's service representative.
    a. Check all removable cells and starter units for easy removal and insertion.
    b. Perform insulation tests on each phase and verify low resistance ground connection on ground bus.
    c. Verify basic operation of each starter from control power source.
    d. Verification of proper torque on all field and factory bolted bus connections. Utilize calibrated torque wrench and submit calibration records with the startup report.
    e. Calibrate any solid-state metering or control relays for their intended purpose and make written notations of adjustments on record drawings.
    f. Follow the manufacturer's instruction and the contract documents concerning any short circuit device settings, HMCP settings or timing relays. All adjustable settings shall be documented and included in the final O & M manual.
3. Submit the manufacturer's field startup report before final payment is made.

H. Training

1. Provide a training session for up to three representatives for 1/2 normal workdays at the job site or other office location chosen by the Owner's Representative.
2. A manufacturer's qualified representative shall conduct the training session.
3. The training program shall consist of the following:
   a. Review of the one-line drawings and schedules.
   b. Review of the factory record shop drawings and placement of the various cells.
   c. Review of each type of starter cell, components within control and power wiring.
   d. Review contactor coil replacement, and contact replacement procedures.
   e. Discuss the maintenance timetable and procedures to be followed in an ongoing maintenance program.
   f. Provide three ring binders to participants complete with copies of drawings and other course material covered.
   g. Full operation, under any and all operating conditions.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install motor controllers according to manufacturer's written instructions.

B. Install conduit in accordance with CSI Division 26 Section 260533, “Raceway and Boxes for Electrical Systems.”

C. Connect power cable and control wire as recommended by manufacturers. Make power cable and control cable connections to manual starters, and across-the-line magnetic starters by means of integral mechanical connectors. If such items are not furnished with integral mechanical connectors, make connections using compression connectors in accordance with CSI Division 26 Section 260519, “Low-Voltage Electrical Power Conductors and Cables.”

D. Ground motor starter in accordance with CSI Division 26 Section 260526, “Grounding and Bonding for Electrical Systems.”

E. Apply touch up paint as necessary.

3.2 IDENTIFICATION

A. Identify motor-control components and control wiring according to CSI Division 26 Section 260553, "Identification for Electrical Systems."

3.3 CONTROL WIRING INSTALLATION

A. Install wiring between motor-control devices according to CSI Division 26 Section 260519, "Low-Voltage Electrical Power Conductors and Cables."

B. Bundle, train, and support wiring in enclosures.

C. Connect hand-off-automatic switch and other automatic control devices where available.

1. Connect selector switches to bypass only the manual and automatic control devices that have no safety functions when switch is in the hand position.

2. Connect selector switches with motor-control circuit in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor overload protectors.

3.4 CONNECTIONS

A. Tighten connectors, terminals, bus joints, and mountings. Tighten field-connected connectors and terminals, including screws and bolts, according to manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.5 FIELD QUALITY CONTROL

A. Inspection and Tests: In addition to any inspection and test requirements noted elsewhere, the following tests are required.

1. The equipment shall be fully assembled, wired and tested at the factory.
2. The motor controllers shall be given visual inspection, wiring checks and operation, continuity, and electric tests for each circuit in accordance with the latest standards of IEEE, NEMA and ANSI, in order to assure completeness, adequacy, and proper functioning equipment. Perform each visual and mechanical inspection and electrical test stated in NETA ATS, Sections 7.5, 7.6, and 7.16 or per manufacturer’s recommendations. Certify compliance with test parameters.
3. Where more than one test is indicated in test code, state by which method the test will be performed.
4. All tests shall be performed in the presence of the DESIGNER. The DESIGNER shall be permitted to inspect any equipment, material or work to be furnished under these specifications and shall have the right to reject any parts considered defective or unsuitable for the use and purpose intended or not in accordance with these specifications.
5. After installing motor controllers and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements. Remove and replace malfunctioning units with new units, and retest.

3.6 CLEANING

A. Remove paint splatters and other spots, dirt, and debris. Touch up scratches and mars of finish to match original finish. Clean devices internally, using methods and materials recommended by manufacturer.

3.7 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup checks according to the approved manufacturer's written instructions.

3.8 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct two 4-hour training sessions. Train the Owner's maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

3.9 EXTRA MATERIALS

A. Furnish to the Engineer spare parts described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. One spare contactor (motor starter) for each ten or less contactors (motor starters) of given size.
2. One set of spare overload heater elements for each ten sets of specific size.
3. Ten percent spare fuses for both primary and secondary of control power transformers.
4. 100 percent replacement of indicating lamps.
5. 50 percent replacement of indicating lamp lenses.

End of Section

Section 26 25 50

GENERATOR DOCKING STATION

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUBMITTALS

A. Product Data: Include rated capacities, weights, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.

C. Manufacturer Seismic Qualification Certification: Submit certification that transfer switches accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based.

D. Field quality-control test reports.

E. Operation and maintenance data.

1.4 QUALITY ASSURANCE

A. Testing Agency Qualifications: Member company of NETA or an NRTL.

B. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. UL (Underwriters Laboratories, Inc.) Standards.

E. Comply with NFPA 70.

1.5 PROJECT CONDITIONS

A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:

1. Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).

2. Altitude: Not exceeding 6600 feet (2010 m).

1.6 COORDINATION

A. Coordinate layout and installation of Generator Docking Station, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

1.7 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers

1. Trystar.
2. ASCO.
3. ESL.
4. Or approved equal.

2.2 BASIS OF DESIGN

A. Basis of Design product shall be Trystar Dual Purpose Docking Station, 2000A rated SBDS-6 Single Breaker Docking Station, Dual Purpose Pass Through with Hardwire and Kirk Key Interlock Alternate Breaker Location.

2.3 DUAL PURPOSE DOCKING STATION

A. Enclosure.

1. NEMA 3R Rain-Tight Aluminum Enclosure
   a. Pad-lockable front door shall include a hinged access plate at the bottom for entry of temporary cabling that prevents unauthorized tampering while in use.
   b. NEMA 3R Integrity shall be maintained while temporary cabling is connected during use.
   c. Front and Side shall be accessible for maintenance.
   d. Top, Side, and Bottom shall be accessible for permanent cabling

2. Powder coat
   a. Paint after fabrication shall be Hammer tone Gray.

B. Phase, Neutral, and Ground Busbar

1. Material: Silver-plated Copper
2. Equipment Ground Bus: bonded to box.
3. Isolated Ground Bus: insulated from box.
4. Ground Bus: 50% of phase size.
5. Neutral Bus: Neutral bus rated 100 percent of phase bus.

C. Temporary generator and Load Bank connectors shall be Camlok style mounted on gland plate.

1. Camlok shall be 16 Series model and color coded according to system voltage requirements.
2. Camlok connections shall be Bus Bar Style, Cabling or Double Set Screw is not acceptable.
3. Camlok connection shall be protected against accidental contact while not in use.
4. All Camlocks must have Protective Flip Covers.

D. Permanent Connection shall be factory installed broad range set-screw mechanical type, located behind a physical barrier.

E. Short Circuit & Withstand Rating

1. Shall be minimum 65 KAIC unless otherwise indicated on drawings.

F. Voltage & Amperage

1. 480/277V, 2000A.

G. Factory Installed Phase Rotation Monitor Device:

1. Phase monitoring relay to be Siemens 3U4512-1AR20 or equal and factory installed.

H. Accessories

1. K - 1 Kirk Key Lock in cabinet, 1 Lock to Ship Loose, 1 Key
2. I - Stainless Steel construction
3. L - Custom lug size
4. N - Strip Heater and Thermostat
5. V - NEC 700.3 Kit

I. Circuit Breaker

1. Must be UL 489 Listed Breaker.
2. Breakers shall be removable for service and maintenance.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine elements and surfaces to receive Generator Docking Station for compliance with installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected

3.2 INSTALLATION

A. Surface, Flush or Base Mounted: Determined by Application

B. Install anchor bolts to elevations required for proper attachment to Generator Docking Station.

3.3 IDENTIFICATION

A. Comply with requirements in Division 26 Section "Identification for Electrical Systems."

B. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.

C. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.4 FACTORY COMMISSIONING

A. Upon completion of the installation, the docking station shall be commissioned by the Manufacturer’s factory authorized technician.

B. Scope of work shall include:

1. Review and verify the installation of all Trystar components and verify the correct electrical flow as depicted on the one-line drawings.
2. The Manufacturer’s authorized technician will set the long time, short time, instantaneous and ground fault protection settings on the Generator Docking Station circuit breaker(s) in accordance with the engineers specifications or as provided as part of the coordination study.
3. Factory training for on-site personnel to educate them on how to connect the generator docking station to a portable generator

4. The Manufacturer’s factory authorized technician shall, upon completion of the commissioning provide a written report to the electrical contractor and electrical engineer indicating the completion of the work.
5. Any issue that is found during the start-up that is determined at that time to be a warranty issue will be covered by Manufacturer. Any issues that are specific to the scope for the electrical installing contractor are the sole responsibility of the installing contractor.
6. Upon successful completion of the commissioning, Trystar will provide a complimentary 12-month warranty extension, above and beyond the 12-month manufacturer warranty.

3.5 FIELD QUALITY CONTROL

A. Third Party Tests and Inspections to include the following:

B. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

C. Prepare test and inspection reports, including a certified report that identifies Generator Docking Station and that describes scanning results. Include notation

3.6 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup check according to the approved manufacturer's written instructions.

3.7 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct two 2-hour training session. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

End of Section

Section 26 27 26

WIRING DEVICES

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. This Section includes the following:

1. Receptacles.
2. Snap switches.
3. Time switches.
4. Outdoor photoelectric switches.
5. Occupancy and daylighting sensor control.
6. Emergency lighting control relay.
7. Lighting contactors.
8. Emergency shunt relay.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: List of legends and description of materials and process used for pre-marking wall plates.

C. Samples: One for each type of device and wall plate specified, in each color specified.

D. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing label warnings and instruction manuals that include labeling conditions.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

1.6 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Subject to compliance with requirements, provide products by one of the following:

1. Legrand; Wiring Devices & Accessories (Legrand).
2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
3. Leviton Mfg. Company Inc. (Leviton).
4. Or approved equal.

B. Basis of Design: the system and materials specified are based upon products by Legrand; and represent the performance standard upon which any equivalent solution shall be based.

2.2 RECEPTACLE OUTLETS:

A. General: All receptacle outlets shall be tamper-resistant.

B. Tamper-Resistant Convenience Receptacles, 125V, 20A: Comply with NEMA WD1, NEMA WD6 configuration 5-20R, UL498 and Federal Specification W-C-596. Prewired pigtail connectors that accommodate Fed Spec receptacles are approved. Must be crimped and welded terminal right-angle application connector.

1. Pass & Seymour: TR5351 (single), TR5362 (duplex), PTTR5362 (use with PTRA6STRNA prewired pigtail connector).

C. Combination Tamper-Resistant Single Convenience Receptacle with (2) USB ports (Type C), 125 V, 20 A and USB power supply of 5Vdc @ 6A, 30W output. cULus Listed, UL Fed Spec Listed. Complies with test requirements UL 498, UL 1310, Fed Spec WC596, CSA C22.2 No. 42, CSA C22.2 No. 223.

1. Pass & Seymour: TR20USBPDW (use with PTRA6STRNA prewired pigtail connector).

D. Controlled Tamper-Resistant Convenience Receptacles, 125V, 20A: Comply with NEMA WD1, NEMA WD6 configuration 5-20R, UL498 and Federal Specification W-C-596.

1. Wireless controlled receptacle, 20A, 125V, NEMA 5-20R; WaveLinx Receptacle [WR-20].

a. Integrated, self-contained unit providing a constant hot plug connection and a controlled plug connection.
b. The wireless controlled receptacle will power downstream receptacles on the same circuit.
c. See specifications Section 260942, Network Lighting Controls.

2. Controlled Tamper-Resistant Convenience Receptacles, 125V, 20A: Comply with NEMA WD1, NEMA WD6 configuration 5-20R, UL498 and Federal Specification W-C-596.
   a. Pass & Seymour: TR5362CH** - 20A top-half controlled.
   b. To be installed downstream and wired from the wireless controlled receptacle on the same circuit.

E. Weather-Resistant Convenience Receptacles, 125V, 20A: Comply with NEMA WD1, NEMA WD6 configuration 5-20R, UL498 and Federal Specification W-C-596. Prewired pigtail connectors that accommodate Fed Spec receptacles are approved. Must be crimped and welded terminal right-angle application connector.

1. Pass & Seymour: WR5362.
2. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with type 3R weather-resistant thermoplastic with lockable while-in-use cover.
   a. Hubbell: MX3200 single gang
   b. Hubbell: MX6200 dual gang

F. Tamper-Resistant GFCI Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD1, NEMA WD6 configuration 5-20R, UL 498, Federal Specification W-C-596 and UL943, Class A, and include indicator light that is lighted when device is tripped.

1. Pass & Seymour: 2097TR.

G. Range Outlet: Straight Blade Devices, Single, 50A 125/250V, 3-Pole 4-Wire Grounding, 14-50R, Flush Mount, Black.

1. Hubbell: RR450F.

H. Dryer Outlet: Straight Blade Devices, Single, 30A 125/250V, 3-Pole 4-Wire Grounding, 14-30R, Flush Mount, Black.

1. Hubbell RR430F.

I. Cord reel sets, description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.

1. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and equipment-rating ampacity plus a minimum of 30 percent.
2. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.
3. Cord reel
   a. Legrand: CRCD123GFCI25R20

4. Furnish and install threaded rods and Unistrut to support cord reels from building structure.

J. Busway cord reel sets, description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.

1. Busway Track:
   a. STARLINE:B60/4-POLE GROUND /60A-3P4W+G).

2. Cord Reel Unit:
   a. STARLINE: DC60-10'-L520x-Provide Cord Reel With Quad Receptacle

3. Furnish and install threaded rods and Unistrut to support busway/cord reels from building structure.
4. Furnish and install Category 6A cable between the HDMI outlets at the large format display and the workstation.

K. Finishes

1. Wiring Devices Connected to Normal Power System: Color by Architect.
2. Wiring Devices Connected to Emergency (Life Safety) Power System: Red.
3. Wiring Devices Connected to Standby Power System: Brown.
4. Controlled outlets: Blue or available color in wireless receptacle version or as directed by the Architect.

2.3 CLOCK BACKBOXES

A. 2-gand back box with cover plate.

1. Legrand: TV2MW

B. Provide 1” EMT conduit stub with pull string from outlet to accessible celling.

C. Furnish and install at each clock location shown on the drawings.

2.4 LARGE FORMAT DISPLAY BACKBOXES

A. Designed to mount along the bottom edge behind a Plasma, LED or LCD display.

B. Large Format Display backboxes shall be manufactured from stamped steel approved for use in new and renovation construction locations. Boxes shall have a polyester based baked enamel finished interior (white). Boxes shall be 11 1/4” L x 4” W x 10 7/8” H [287mm x 102mm x 275mm]. Provide boxes with four (4) independent wiring compartments that allow for up to four (4) receptacles, communication and/or audio/video services. Boxes shall have removable and relocatable dividers to permit custom configuration of compartments as well as permit feed to adjacent compartments. Boxes shall permit feed to compartments on the opposite side of the box through a tunnel. The box shall be provided with two (2) removable device compartments to facilitate installation and moves, additions, and changes. The cable pass-through area shall be a minimum of 2.4 in2 [1560mm2] per channel. The box shall contain the following number of knockouts: four (4) 1-1/4” trade size, two (2) 3/4” trade size, and two (2) 2” trade size. The box shall be provided with a trim ring and decorative cover. The trim flange shall have an epoxy coating (white) that can be field painted. The decorative cover shall be made out of steel .048” [1.2mm] thickness minimum. The cover shall have an epoxy coating (white) that can be field painted. The box shall be able to accept 2-3/4” x 4-1/2” standard size wall plates. Include

mounting brackets with the boxes that will accommodate 20A straight blade receptacles, Ortronics® workstation connectivity and modular adapters, a variety of audio/video devices from most manufacturers, and other open system devices.

C. Furnish and install at each TV location shown on the drawings.

1. Legrand: EFSB4

D. Furnish and install Connectors and 41900-XX High Speed HDMI Cables between the large format display backboxes and AV outlets shown on the drawings (TVHC, TVHL and TVHF locations).

1. HDMI Outlet: Auto-switching AV HDBaseT transmitters with (3) HDMI Ports
   a. Hubbell: ISFHDT431BK

2. USB Charger Tamper Resistant Receptacle, (1) USB Port 3A, 5V DC output, 15A, 125V AC Decorator Duplex
   a. Hubbell: AVPS15xx
   b. The 5V DC output shall power the HDMI outlet.

E. Furnish and install at the security workstation:

1. HDMI Outlet: Auto-switching AV HDBaseT transmitters with (3) HDMI Ports
   a. Hubbell: ISFHDT431BK

2. USB Charger Tamper Resistant Receptacle, (1) USB Port 3A, 5V DC output, 15A, 125V AC Decorator Duplex
   a. Hubbell: AVPS15xx
   b. The 5V DC output shall power the HDMI outlet.

3. Two Gang AV Wallboxes
   a. Hubbell: HBL985

4. Low Voltage Divider
   a. Hubbell: HBL989

2.5 SNAP SWITCHES

A. Comply with NEMA WD 1 and UL 20.

B. Switches, 120/277 V, 20 A:

1. Pass & Seymour; CSB20AC1 (single pole), PT20AC1 (single pole – use with PTS6STR3 prewired pigtail connector), CSB20AC2 (two pole), CSB20AC3 (three way), PT20AC3 (three way – use with PTS6STR4 prewired pigtail connector), CSB20AC4 (four way).

C. Pilot Light Switches, 120/277 V, 20 A:

1. Pass & Seymour; PS20AC1RPL for 120V, PS20AC1RPL7 for 277V.

D. Key-Operated Switches, 120/277 V, 20 A:

1. Pass & Seymour; PS20AC1-L.

E. Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors.

1. Pass & Seymour; 1251.

F. Finishes

1. Color by Architect.

2.6 WALL PLATES

A. Single and combination types:

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: Stainless Steel.
3. Material for Unfinished Spaces: Galvanized steel.
4. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in "wet locations."

2.7 FLOOR SERVICE FITTINGS

A. Power/Communications/AV – Floor Box Floor Service (concrete, raised and wood floors):

1. The floor box shall be utilized for floor power and communications to accommodate duplex receptacles, voice/data outlets and AV outlets.
2. Provide where shown on the drawings with face plates and cover assembly. Cover color and type shall be as directed by the Architect.
3. Modular, flush-type, dual-service units suitable for wiring method used.
4. Compartments: Barrier separates power from communications cabling.
5. Furnish and install one 3/4" conduit for power and two 1-1/2” conduits for communications. Run conduits to the nearest wall and stub up above accessible ceiling. Provide bushings and pull string in all conduits.
6. Coordinate with the structural engineer for the maximum size of the conduit allowed to run in the slab. In the event that conduits larger than 3/4" or 1-1/2” are not allowed to run in the slab, run conduits in the ceiling of the floor below or under the slab.
7. Basis of Design: Legrand EFB6S Series, Legrand EFB6S-OG (Ground), and Legrand EFB6S-FC (fire classified).

B. Power/Communications – Floor Box Furniture Feed (concrete, raised and wood floors):

1. The floor box shall be utilized for floor power and communications to accommodate duplex receptacles and voice/data outlets.
2. Provide where shown on the drawings with face plates and cover assembly. Cover color and type shall be as directed by the Architect.
3. Modular, flush-type, dual-service units suitable for wiring method used.
4. Compartments: Barrier separates power from communications cabling.
5. Furnish and install one 1" conduit for power and one 2” conduit for communications. Run conduits to the nearest wall and stub up above accessible ceiling. Provide bushings and pull string in all conduits.
6. Furnish and install power and telecommunications whips to the powered furniture.
7. Coordinate electrical work associated with the powered furniture delivery so that the work is scheduled to be performed when the powered furniture is delivered and assembled on site.

8. Run telecommunications wiring in the modular furniture, furnish and install outlet jacks and faceplates, terminate and test all devices.
9. The work shall be scheduled and performed at no additional cost to the Owner.
10. Basis of Design: Legrand EFBFF- FPFFTC Series.

C. Power/Communications/AV - Poke-Thru Floor Service:

1. The poke-thru service device shall be utilized for floor power, communications and AV to accommodate up to two duplex receptacles, six voice/data outlets and AV outlets.
2. Provide where shown on the drawings with 5-20R receptacles, voice/data outlets and AV outlets together with face plates and die-cast aluminum cover assembly. Color shall be as directed by the Architect.
3. Modular, flush-type, dual-service units suitable for wiring method used.
4. Compartments: Barrier separates power from communications cabling.
5. Furnish and install 3/4" bottom housing assembly for power and two 1-1/2” bottom housing assembly for communications. Provide bushings and pull string in all conduits.
6. Run conduits in the ceiling of the floor below.
7. Basis of Design: Legrand 8AT Series.

D. Power/Communications - Poke-Thru Furniture Feed:

1. The poke-thru service device shall be utilized for floor power and communications to accommodate up to two duplex receptacles and six voice/data outlets.
2. Provide where shown on the drawings.
3. Modular, flush-type, dual-service units suitable for wiring method used.
4. Compartments: Barrier separates power from communications cabling.
5. Furnish and install 3/4" bottom housing assembly for power and 2” conduit bottom housing assembly for communications. Provide bushings and pull string in all conduits.
6. Run conduits in the ceiling of the floor below.
7. Furnish and install power and telecommunications whips to the powered furniture.
8. Coordinate electrical work associated with the powered furniture delivery so that the work is scheduled to be performed when the powered furniture is delivered and assembled on site.
9. Run telecommunications wiring in the modular furniture, furnish and install outlet jacks and faceplates, terminate and test all devices.
10. The work shall be scheduled and performed at no additional cost to the Owner.
11. Basis of Design: Legrand 6AT Series.

E. Power/Communications – Poke-Thru Transient Locations

1. This assembly shall be made up of an insert and an activation cover. Overall poke-thru assembly length shall be 16" 3/8” [416mm].
2. Insert:
   a. The insert body shall have the necessary channels to provide complete separation of power and communication services. There shall be one 3/4" trade size channel for power and two 1/2" trade size channels for communication cabling. The channels shall be arranged such that communication cables can be conduit protected and connected to the insert body using a die-cast zinc conduit connector with two 1/2" trade size threaded openings to accept both rigid and flexible conduit connections.
   b. The insert shall also consist of two 20-amp duplex receptacles. The four receptacles shall be prewired with six #12 AWG THHN solid conductors. Each duplex receptacle shall be wired with individual neutral and individual ground wires. The power receptacles shall be capable of being wired as standard

receptacles or for isolated ground. Circuit identifiers shall be clearly marked on each duplex receptacle and a wiring diagram shall be stamped inside the junction box.

c. The insert body shall also contain a nonmetallic bracket that will accommodate Ortronics workstation connectivity modular inserts, or the Pass & Seymour Network Wiring Systems. The bracket shall allow the inserts to mount flush and recessed.

d. The body will consist of an intumescent fire stop material to maintain the fire rating of the floor slab. The intumescent material will be held securely in place in the insert body and shall not have to be adjusted to maintain the fire rating of the unit and the floor slab. The insert shall have a spring steel-retaining ring that will hold the poke-thru device in the floor slab without additional fasteners. The poke-thru insert shall also consist of a 3/4" trade size conduit stub that is connected to the insert body and a 24.5 cubic inch [402ml] stamped steel junction box for wire splices and connections. The stamped steel junction box shall also contain the necessary means to electrically ground the poke-thru device to the system ground.

3. Activation Cover:

a. The trim flange shall be manufactured of die-cast aluminum alloy and be capable of being powder-coated or plated. The coated finish is to be textured, two-stage epoxy paint in gray, black, or ivory. A gasket is attached to the underside of the trim flange to maintain scrub water tightness. The trim flange shall also be available in a solid brass forging and a die cast brushed aluminum finish. Brass and aluminum finish shall be a brushed finish with a lacquer sealant. The trim flange shall be 8 1/4" [210mm] in diameter. The activation slide cover shall be 6 1/4" [159mm] in diameter.

b. The activation cover shall be manufactured from textured Polycarbonate or PVC and be available in gray, black, ivory, and brass colors. The slide holder assembly shall be flush with the floor and provide “Dead-front” protection that allows the receptacle covers to snap back into place when receptacle is not in use. A gasket is attached to the underside of the cover assembly to maintain scrub water tightness by preventing water, dirt, and debris from entering the power and communication compartments. The device shall also have accommodation for up to four communication connectors. The cover shall have individual slides that allow access to the communication connectors and will close over the connectors when not in use. Each activation cover shall also provide locations to adhere labels to identify both power and communication circuits.

4. Communication Modules Mounting Accessories:

a. The poke-thru device manufacturer shall provide a complete line of bezels to facilitate mounting of UTP, STP (150 ohm), fiber optic, coaxial, and communication devices. Communication connectors shall be capable of being installed either flush or recessed. For communications, the unit will contain accommodations for up to four connectors for UTP, fiber optic, coaxial, audio, and video solutions. The poke-thru device shall accommodate Ortronics workstation connectivity outlets and modular inserts or the Pass & Seymour Network Wiring System. To accommodate the communication solutions, the device shall accept discrete keystone type connectivity devices from various manufacturers. All communication inserts shall be nonmetallic. The system shall provide for connection of other modular inserts for additional communication options. The unit will also be supplied with four Category 6 keystone connectors with the standard version. The unit shall also accommodate a mechanism to permit protection of communication cabling. This mechanism shall be zinc die-cast with two openings to accept both flexible and rigid conduit. Openings shall accept 1/2" trade size conduit

5. Basis of Design: Legrand RC4 Series.

F. Installation

1. Preparation

a. Prepare substrates using the methods recommended by the manufacturer for achieving the best result for the substrate under the project conditions.

b. If preparation is the responsibility of another installer, notify Architect in writing of deviations from manufacturer’s recommended installation tolerances and conditions.

2. General

a. Install in accordance with manufacturer's instructions for system components and approved shop drawings. Coordinate installation with adjacent work to ensure proper clearances and to prevent electrical hazards.

b. Install in accordance with complete system instruction sheets.

c. Install enclosures to be mechanically continuous and connected to all electrical outlets, boxes, device mounting brackets, and cabinets, in accordance with manufacturer's installation sheets.

d. Install enclosures to be electrically continuous and bonded in accordance with the National Electric Code for proper grounding.

e. Mechanical Security: Raceway systems shall be mechanically continuous and connected to all electrical outlets, boxes, device mounting brackets, and cabinets, in accordance with manufacturer’s installation sheets.

f. Electrical Security: Metal raceway shall be electrically continuous and bonded in accordance with the National Electric Code for proper grounding.

g. Raceway Support: Raceway shall be supported at intervals not exceeding 5 feet (1524 mm) or in accordance with manufacturer’s installation sheets.

h. Accessories: Provide accessories as required for a complete installation, including insulated bushings and inserts where required by manufacturer.

i. Unused Openings: Close unused raceway openings using manufacturer's recommended accessories.

j. Install floor boxes to permit all wiring to be completed at floor level.

3. Protection

a. Clean exposed surfaces using non-abrasive materials and methods recommended by manufacturer.

b. Protect installed products until completion of project.

c. Touch-up, repair or replace damaged products before Substantial Completion.

2.8 OUTDOOR GROUND BOX

A. Provide underground power/communications box as shown on the drawings.

B. Classification and Use: Outdoor ground boxes shall have been examined and tested by Underwriters Laboratories Inc. to meet NEMA 6P and IP68 requirements to be safe to use even during inclement weather and bear the cULus Listing Mark.

C. Outdoor Ground Boxes, General:

1. Outdoor ground boxes shall be designed to trap and maintain an air pocket to protect the devices, plugs and connections from water, snow, and ice. Boxes shall be constructed from UV rated chemical resistant materials. Boxes designed to ANSI/SCTE 77 with a Tier 5 rating to hold up to 5000 lbs of load. Boxes install flush to finished ground reducing tripping hazards. Box shall have a diving bell concept to maintain an air pocket and keep water away from connections. Box shall have an egress door that will auto-adjust to cable diameter and auto-lock in the closed position when no cables are exiting the box.
2. Basis of Design Product: Legrand Model XB814 box (5-20R receptacles) and XB814C520-BK Exterior Box Cover Assembly: Assembly prewired with two (2) 20A L5-20R weather-resistant duplex receptacles. Box assemblies shall be 16-1/8" L x 8-1/16" W x 10-3/4" H [410mm x 205mm x 273mm]. Cover assembly includes flange, cover, junction box, (2) 20A 5-20R receptacles, SOOW cord, wet location wire connectors, key, and mounting hardware.
3. Basis of Design Product: Legrand Model XB814 box (Low Voltage) and XB814CLV-BK Exterior Box Cover Assembly: Assembly designed to accept up to 12 communication ports. Cover assemblies shall be 16-1/8" L x 8-1/16" W x 10-3/4" H [410mm x 205mm x 273mm]. Cover assembly includes flange, cover, junction box, corrugated conduit assembly, (1) 12 port communication mounting plate, (1) 8 port Legrand AVIP audio/video mounting plate, key, and mounting hardware.

D. Installation

1. Strictly comply with manufacturer's installation instructions and recommendations. Coordinate installation with adjacent work to ensure proper clearances and to prevent electrical hazards.

E. Cleaning and Protection

1. Clean exposed surfaces using non-abrasive materials and methods recommended by manufacturer.
2. Protect boxes until acceptance.

2.9 TIME SWITCHES

A. Electronic Time Switches: Electronic, solid-state programmable units with alphanumeric display; complying with UL 917.

1. Contact Rating: 20-A ballast load, 120/240-V ac.
2. Program: 8 on-off set points on a 24-hour schedule and an annual holiday schedule that overrides the weekly operation on holidays.
3. Program: 2 on-off set points on a 24-hour schedule, allowing different set points for each day of the week and an annual holiday schedule that overrides the weekly operation on holidays.
4. Programs: 2 channels; each channel shall be individually programmable with 8 on-off set points on a 24-hour schedule.
5. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program on selected channels.
6. Astronomic Time: Selected channels.

7. Battery Backup: For schedules and time clock.

B. Electromechanical-Dial Time Switches: Type complying with UL 917.

1. Contact Rating: 20-A ballast load, 120/240-V ac.
2. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program.
3. Astronomic time dial.
4. Eight-Day Program: Uniquely programmable for each weekday and holidays.
5. Skip-a-day mode.
6. Wound-spring reserve carryover mechanism to keep time during power failures, minimum of 16 hours.

2.10 OUTDOOR PHOTOELECTRIC SWITCHES

A. Description: Solid state, with dry contacts rated for 1800-VA tungsten or 1000-VA inductive, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A.

1. Light-Level Monitoring Range: 1.5 to 10 fc (16.14 to 108 lx), with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of photocell to prevent fixed light sources from causing turn-off.
2. Time Delay: 15-second minimum, to prevent false operation.
3. Surge Protection: Metal-oxide varistor, complying with IEEE C62.41.1, IEEE C62.41.2, and IEEE 62.45 for Category A1 locations.
4. Mounting: Twist lock complying with IEEE C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.

B. Description: Solid state, with dry contacts rated for 1800 VA to operate connected load, relay, or contactor coils; complying with UL 773.

1. Light-Level Monitoring Range: 1.5 to 10 fc (16.14 to 108 lx), with an adjustment for turn-on and turn-off levels within that range.
2. Time Delay: 30-second minimum, to prevent false operation.
3. Lightning Arrester: Air-gap type.
4. Mounting: Twist lock complying with IEEE C136.10, with base.
5. Photo Sensor: Cadmium sulfide.
6. Provide external sliding shield for field adjustment of light level activation.
7. Voltage: As required to control the load indicated on the drawings.
8. Failure Mode: Fails to the on position.
9. Load Rating: As required to control the load indicated on the drawings.
10. Provide accessory wall-mounting bracket where indicated or as required to complete installation

2.11 CONTACTORS

A. Description: Electrically operated and electrically held, combination type with fusible switch, complying with NEMA ICS 2 and UL 508.

1. Current Rating for Switching: Listing or rating consistent with type of load served, including tungsten filament, inductive, and high-inrush ballast (ballast with 15 percent or less total harmonic distortion of normal load current).
2. Fault Current Withstand Rating: Equal to or exceeding the available fault current at the point of installation.
3. Enclosure: Comply with NEMA 250.
4. Provide with control and pilot devices as indicated on Drawings, matching the NEMA type specified for the enclosure.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that field measurements are as shown on the drawings.

B. Verify that outlet boxes are installed in proper locations and at the proper heights and are properly sized to accommodate devices and conductors in accordance with NFPA 70.

C. Verify that openings for outlet boxes are neatly cut and will be completely covered by devices or wall plates.

D. Verify that final surface finishes are complete, including painting.

E. Verify that branch circuit wiring installation is completed, tested, and ready for connection to lighting control devices.

F. Verify that the service voltage and ratings of lighting control devices are appropriate for the service voltage and load requirements at the location to be installed.

G. Verify that conditions are satisfactory for installation prior to starting work.

3.2 PREPARATION

A. Provide extension rings to bring outlet boxes flush with finished surface.

B. Clean dirt, debris, plaster, and other foreign material from outlet boxes.

3.3 INSTALLATION

A. Perform work in a neat and workmanship manner in accordance with NECA 1 and where applicable, NECA 130, including mounting heights specified in those standards unless otherwise indicated.

A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.

B. Coordination with Other Trades:

1. Take steps to ensure that devices and their boxes are protected. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of the boxes.
2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
4. Existing Conductors:
   a. Cut back and pigtail, or replace all damaged conductors.
   b. Straighten conductors that remain and remove corrosion and foreign matter.
   c. Pigtailing existing conductors is permitted provided the outlet box is large enough.

D. Device Installation:

1. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
4. Connect devices to branch circuits using pigtails that are not less than 6 inches (152 mm) in length.
5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
8. Tighten unused terminal screws on the device.
9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.

E. Receptacle Orientation:

1. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the left.

F. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

G. Dimmers:

1. Install dimmers within terms of their listing.

2. Verify that dimmers used for fan speed control are listed for that application.
3. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.

H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multi-gang wall plates.

I. Install lighting control devices in accordance with manufacturer’s instructions.

J. Unless otherwise indicated, connect lighting control device grounding terminal or conductor to branch circuit equipment grounding conductor and to outlet box with bonding jumper.

K. Install lighting control devices plumb and level, and held securely in place.

L. Where applicable, install lighting control devices and associated wall plates to fit completely flush to mounting surface with no gaps and rough opening completely covered without strain on wall plate. Repair or reinstall improperly installed outlet boxes or improperly sized rough opening. Do not use oversized wall plates in lieu of meeting this requirement.

M. Occupancy Sensor Locations:

1. Location Adjustments: Within the design intent, reasonably minor adjustments to locations may be made in order to optimize coverage nd avoid conflicts or problems affecting coverage.
2. Locate ultrasonic and dual technology passive infrared/ultrasonic occupancy sensors a minimum 4 feet from air supply ducts or other sources of heavy air flow and as per manufacturers recommendations, in order to minimum false triggers.

N. Outdoor Photo Control Locations:

1. Where possible, locate outdoor photo controls with photo sensor facing north. If north facing photo sensor is not possible, install photo sensor facing east, west or down.
2. Locate outdoor photo controls so that photo sensor do not face artificial light sources, including light sources controlled by the photo control itself.

O. Install outdoor photo controls so that connections are weatherproof. Do not install photo controls with conduit stem facing up in order to prevent infiltration of water into the photo control.

P. Lamp Burn-in: Operate lamps at full output for minimum of 100 hours or prescribed period per manufacturer’s recommendation prior to use with any dimming controls. Replace lamps that fail prematurely due to improper lamp burn-in.

Q. Unless otherwise indicated, install power packs for lighting control devices above accessible ceiling or above access panel inaccessible ceiling near the sensor location.

R. Where indicated, install separate compatible wall switches for manual control interface with lighting control devices or associated power packs.

S. Unless otherwise indicated, install switches on load side of power packs so that switch does not turn off power pack.

T. Where indicated or required, provide cabinet or enclosure for mounting of lighting control device system components.

3.4 IDENTIFICATION

A. Comply with Division 26 Section "Identification for Electrical Systems."

1. Receptacles: Identify panelboard and circuit number from which served. Use hot, stamped or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.5 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

1. Test Instruments: Use instruments that comply with UL 1436.
2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

B. Tests for Convenience Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is not acceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new, and retest as specified above.

C. Lighting Control:

1. Inspect each lighting control device for damage and defects.
2. Test occupancy sensors to verify operation, including time delays and ambient light thresholds where applicable. Verify optimal coverage for entire room or area. Record test results in written report to be included with submittals.
3. Test outdoor photo controls to verify proper operation, including time delays where applicable.
4. Correct wiring deficiencies and replace damaged or defective lighting control devices.

3.6 ADJUSTING

A. Adjust devices and wall plates to be flush and level.

B. Adjust occupancy sensors settings to minimize undesired activations while optimizing energy savings, and to achieve optimal coverage as required.

C. Where indicated or as directed by Architect/Engineer, install factory masking material or adjust integral blinders on passive infrared (PIR) and dual technology occupancy sensor lenses to block undesired motion detection.

D. Adjust external sliding shields on outdoor photo controls under optimum lighting conditions to achieve desired turn-on and turn-off activation as indicated or as directed by Architect/Engineer.

3.7 CLEANING

A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

3.8 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup checks according to the approved manufacturer's written instructions.

3.9 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct two 4-hour training sessions. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

3.10 SPARE PARTS

A. Furnish the following component at the end of the project to the Owner:

1. Receptacles: 20
2. USB receptacles: 20
3. Controlled receptacles: 20
4. GFCI receptacles: 20
5. Wall plate: 20

End of Section

Section 26 27 29

ELECTRIC VEHICLE CHARGING STATION

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. Provide design and engineering, labor, material, equipment, related services, and supervision required, including, but not limited to, manufacturing, fabrication, erection, and installation for electric vehicle (EV) charging stations as required for the complete performance of the work, and as shown on the Drawings and as herein specified.

B. The work specified in this Section includes, but shall not be limited to, complete, electric vehicle charging stations as indicated on the Drawings and as specified herein.

1. The extent of the electric vehicle charging infrastructure work shall be as indicated by the Drawings and by the requirements of this Section, including, but not limited to, the following:
   a. Power distribution equipment, underground conduit, concrete bases, wiring and commissioning.
   b. Workstations, software, and communications hardware.

2. System installation shall include, but shall not be limited to, the following:
   a. Wiring of branch circuit conductors.
   b. Installation of charging stations.
   c. Installation of communications conductors and associated hardware.
   d. Configuration of software for payment service.

C. REFERENCES

1. American Society of Civil Engineers (ASCE):
   a. ASCE 7, "Minimum Design Loads for Buildings and Other Structures" (copyrighted by ASCE, ANSI approved).

2. ASTM (ASTM):
   a. ASTM E 329, "Standard Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction."

3. California Code of Regulations (CCR):
   a. CCR Title 24, “California Building Standards Code.”

4. International Code Council (ICC):
   a. ICC ES AC156, “Acceptance Criteria for Seismic Qualification by Shake Table Testing of Nonstructural Components and Systems.”
   b. ICC IBC, "International Building Code."

5. National Fire Protection Association (NFPA):
   a. NFPA 70, "National Electrical Code" (copyrighted by NFPA, ANSI approved) hereinafter referred to as NEC.
   b. NFPA 5000, “Building Construction and Safety Code.”

6. SAE International (SAE):
   a. SAE J1772, "Standard for Electric Vehicle Conductive Charge Coupler."

7. Underwriters Laboratories, Inc. (UL):
   a. UL 991, "Standard for Tests for Safety Related Controls Employing Solid State Devices."
   b. UL 1998, "Standard for Software in Programmable Components."
   c. UL 2231 1, "Standard for Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits: General Requirements."
   d. UL 2231 2, "Standard for Personnel Protection Systems for Electric Vehicle (EV) Supply Circuits: Particular Requirements for Protection Devices for Use in Charging Systems."
   e. UL 2251, "Standard for Plugs, Receptacles and Couplers for Electric Vehicles."
   f. UL 2594, "Standard for Electric Vehicle Supply Equipment.”

1.4 SUBMITTALS

A. Product Data: Submit product data showing material proposed. Submit sufficient information to determine compliance with the Drawings and Specifications, including, but not limited to, manufacturer's product data and installation instructions for each component and system.

B. Shop Drawings: Submit shop drawings for each product and accessory required. Include information not fully detailed in manufacturer’s standard product data, including, but not limited to, list of components and equipment to be supplied, including, but not limited to, proposed locations, clearances, and power requirements.

   1. Drawings: Submit manufacturer’s dimensional drawings.
   2. One Line Diagrams: Submit one line diagrams of the system configuration proposed if it differs from that illustrated in the riser diagram included in these Construction Documents. Submit one line drawings indicating location and addresses of all hardware, including, but not limited to, panelboard or load center, circuit breaker, and charging stations.

C. Wiring Diagrams: Submit wiring diagrams detailing power, signal, and control systems, clearly differentiating between manufacturer installed wiring and field installed wiring, and between components provided by the manufacturer and those provided by others.

1. Submit typical connection diagrams for all components including, but not limited to, panelboards, communications devices, and personal computers.

D. Qualification Data: Submit qualification data for firms and persons specified in Quality Assurance Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names of architects and owners, and other information specified.

E. Contract Closeout Submittals:

1. Operation and Maintenance Data: Submit operation and maintenance data for electric vehicle charging stations.
2. Warranty Data: Submit manufacturer's standard warranty documents.

1.5 QUALITY ASSURANCE

A. Qualifications

1. Manufacturer Qualifications: Manufacturer shall be a firm engaged in the manufacture of electric vehicle charging stations of types and sizes required, and whose products have been in satisfactory use in similar service for a minimum of 10 years.
   a. The manufacturer shall be ISO 9001 certified and shall be designed to internationally accepted standards.
   b. Factory fax/telephone/email system support shall be available free of charge from the manufacturer during normal business hours.

2. Installer Qualifications: Installer shall be a firm that shall have a minimum of five years of successful installation experience with projects utilizing electric vehicle charging stations similar in type and scope to that required for this Project and shall be approved by the manufacturer.
3. Inspecting and Testing Agency Qualifications: To qualify for acceptance, an independent inspecting and testing agency hired by the Contractor or manufacturer to test products shall demonstrate to the Architect/Engineer’s satisfaction that they are qualified according to ASTM E 329 to conduct testing indicated.

B. Regulatory Requirements: Comply with applicable requirements of the laws, codes, ordinances, and regulations of Federal, State, and local authorities having jurisdiction. Obtain necessary approvals from such authorities.

C. Standards: Comply with applicable requirements of the following standards:

1. NEMA Compliance: Applicable portions of NEMA standards pertaining to types of electrical equipment and enclosures.
2. NEC Compliance: Applicable portions of the NEC.
3. UL Compliance: Applicable UL standards for electric vehicle supply equipment, panelboards, circuit breakers, and energy management equipment.
4. FCC Emissions: Comply with FCC emissions standards.
5. Seismic Compliance: NFPA 5000, ASCE 7, ICC ES AC156, and/or ICC IBC, as applicable to the Project location and as required by authorities having jurisdiction.

D. Electrical Components, Devices, and Accessories: Electrical components, devices, and accessories shall be listed and labeled as defined in NEC, Article 100, by an inspecting and testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. Pre Installation Conference: Prior to commencing the installation, meet at the Project site to review the material selections, installation procedures, and coordination with other trades. Pre-installation conference shall include, but shall not be limited to, the Contractor, the Installer, and any trade that requires coordination with the work. Date and time of the pre-installation conference shall be acceptable to the Owner and the Architect/Engineer.

F. Coordination: Coordinate the work in this Section with all of the trades covered in other sections of the Specification to provide a complete and operable system. Furnish inserts and anchors that must be built into other work. Work closely with installers of finish materials so that units are properly aligned with adjacent materials.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to the Project site in supplier's or manufacturer's original wrappings and containers, labeled with supplier's or manufacturer's name, material or product brand name, and lot number, if any.

B. Store materials in their original, undamaged packages and containers, inside a well ventilated area protected from weather, moisture, soiling, extreme temperatures, and humidity.

1.7 PROJECT CONDITIONS

A. Environmental Requirements: Do not install electric vehicle charging stations until space is enclosed and weatherproof, wet work in space is completed and nominally dry, work above ceilings is complete, and ambient temperature and humidity conditions are and will be continuously maintained at values near those indicated for final occupancy.

1.8 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers

1. ChargePoint.
2. Nuvve.
3. Coritech.
4. Or approved equal.

B. Basis of Design: The system and materials specified are based upon products by ChargePoint; and represent the performance standard upon which any equivalent solution shall be based.

2.2 ELECTRIC VEHICLE SUPPLY EQUIPMENT (EVSE)

A. Product specified is “Electric Vehicle (EV) Charging Station” Charge Point CT4000 Family

1. Model CT4021-GW1 Dual Port Bollard USA Gateway Station with Concrete Mounting Kit CY4001-CCM.
2. Connectivity:
   a. Local Area Network: 2.4 GHz Wi-Fi (802.11 b/g/n)
   b. Wide Area Network: 3G GSM, 3G CDMA
3. Power management kit: CT4000-PMGMT
4. ChargePoint Commercial Service Plan, 3 Year Subscription CTSW-SAS-COMM-3.
5. ChargePoint Station Installation and Validation CT4000-INSTALLVALID.
6. ChargePoint Station Activation and Configuration CPSUPPORT-ACTIVE.
7. ChargePoint Assure CT4000-ASSURE3.

B. Electrical Input

1. Input Current: 30A x 2.
2. Input Power Connection: Two independent 40A branch circuits.
3. Required Service Panel Breaker: 40A dual pole (non-GFCI type) x 2.
4. Service Panel GFCI: Do not provide external GFCI as it may conflict with internal GFCI (CCID).
5. Wiring – Standard: 5-wire (L1, L1, L2, L2, Earth).
6. Station Power: 8W typical (standby), 15W maximum (operation).

C. Electrical Output

1. Output: 7.2kW (240V AC@30A) x 2.

D. Functional Interfaces

1. Connector(s) Type: SAE J1772™ x 2.
2. Cable Length - 2440 mm (8') Cable Management: 7 m (23').
3. Overhead Cable Management System: Yes.
4. LCD Display: 145 mm (5.7") full color, 640x480, 30fps full motion video, active matrix, UV protected.
5. Card Reader: ISO 15693, ISO 14443, NFC.
6. Locking Holster: Yes x 2.

E. Safety and Connectivity Features

1. Ground Fault Detection: 20mA CCID with auto retry.
2. Open Safety Ground Detection: Continuously monitors presence of safety (green wire) ground connection.
3. Plug-Out Detection: Power terminated per SAE J1772™ specifications.
4. Power Measurement Accuracy: +/- 2% from 2% to full scale (30A).
5. Power Report/Store Interval: 15 minute, aligned to hour.
6. Local Area Network: 2.4 GHz Wi-Fi (802.11 b/g/n).
7. Wide Area Network: 3G GSM, 3G CDMA.

F. Safety and Operational Ratings

1. Enclosure Rating: Type 3R per UL 50E.

2. Safety Compliance: UL listed for USA and cUL certified for Canada; complies with UL 2594, UL 2231-1, UL 2231-2, and NEC Article 625.
3. Surge Protection: 6kV @ 3000A. In geographic areas subject to frequent thunder storms, supplemental surge protection at the service panel is recommended.
4. EMC Compliance: FCC Part 15 Class A.
5. Operating Temperature: -30°C to +50°C (-22°F to 122°F).
6. Storage Temperature: -30°C to +60°C (-22°F to 140°F).
7. Non-Operating Temperature: -40°C to +60°C (-40°F to 140°F).
8. Operating Humidity: Up to 85% @ +50°C (122°F) non-condensing.
9. Non-Operating Humidity: Up to 95% @ +50°C (122°F) non-condensing.
10. Terminal Block Temperature Rating: 105°C (221°F).
11. Charging Stations per 802.11 Radio Group: Maximum of 10. Each station must be located within 45m (150') “line of sight” of a gateway station.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verification of Conditions: Examine areas and conditions under which the work is to be installed, and notify the Contractor in writing, with a copy to the Owner and the Architect/Engineer, of any conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected.

1. Beginning of the work shall indicate acceptance of the areas and conditions as satisfactory by the Installer.

3.2 INSTALLATION

A. Preparation and installation shall be in accordance with reviewed product data, final shop drawings, manufacturer’s written instructions and recommendations, and as indicated on the Drawings. System installation shall be coordinated with related and adjacent work.

3.3 PROTECTION

A. Provide final protection and maintain conditions in a manner acceptable to the Installer, that shall ensure that the electric vehicle charging stations shall be without damage at time of Substantial Completion.

3.4 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup checks according to the approved manufacturer's written instructions.

3.5 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct two 4-hour training sessions. Train the Owner's maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

End of Section

Section 26 28 13

FUSES

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. This Section includes the following:

1. Cartridge fuses rated 600 V and less for use in controllers and motor-control centers.

1.4 SUBMITTALS

A. Product Data: For each fuse type indicated.

B. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NEMA FU 1.

C. Comply with NFPA 70.

1.6 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers

1. Bussman, Inc.
2. Eagle Electric Mfg. Co., Inc.; Cooper Industries, Inc.
3. Ferraz Shawmut, Inc.
4. Or approved equal.

2.2 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, nonrenewable cartridge fuse; class and current rating indicated; voltage rating consistent with circuit voltage.

PART 3 - EXECUTION

3.1 FUSE APPLICATIONS

A. Motor Branch Circuits: Class RK1/RK5, time delay.

3.2 INSTALLATION

A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

3.3 IDENTIFICATION

A. Install labels indicating fuse replacement information on inside door of each fused switch.

3.4 EXTRA MATERIALS

A. Ten percent spare fuses. Provide a minimum of three of each type.

End of Section

Section 26 28 16

ENCLOSED SWITCHES AND CIRCUIT BREAKERS

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. This Section includes the following individually mounted, enclosed switches and circuit breakers:

1. Fusible switches.
2. Non-fusible switches.
3. Molded-case circuit breakers.
4. Enclosures.

1.4 SUBMITTALS

A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated.

B. Shop Drawings: Diagram power, signal, and control wiring.

C. Field quality-control test reports.

D. Operation and maintenance data.

1.5 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

1.6 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 FUSIBLE AND NONFUSIBLE SWITCHES

A. Approved Manufacturers

1. Eaton Corporation; Cutler-Hammer Products.
2. General Electric Co.; Electrical Distribution & Control Division.
3. Square D/Group Schneider.
4. Or approved equal.

B. Fusible Switch, 1200A and Smaller: NEMA KS 1, Type HD, with clips or bolt pads to accommodate specified fuses, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

C. Non-fusible Switch1200 A and Smaller: NEMA KS 1, Type HD, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.

D. Accessories:

1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
2. Neutral Kit: Internally mounted; insulated, capable of being grounded, and bonded; and labeled for copper and aluminum neutral conductors.
3. Auxiliary Contact Kit: Auxiliary set of contacts arranged to open before switch blades open.

2.2 MOLDED-CASE CIRCUIT BREAKERS AND SWITCHES

A. Manufacturers:

1. Eaton Corporation; Cutler-Hammer Products.
2. General Electric Co.; Electrical Distribution & Control Division.
3. Square D/Group Schneider.
4. Or approved equal.

B. Molded-Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.

1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.

3. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller and let-through ratings less than NEMA FU 1, RK-5.
4. GFCI Circuit Breakers: Single- and two-pole configurations with [5] [30]-mA trip sensitivity.

C. Molded-Case Circuit-Breaker Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Mechanical style suitable for number, size, trip ratings, and conductor material.
3. Application Listing: Type SWD for switching fluorescent lighting loads; Type HACR for heating, air-conditioning, and refrigerating equipment.
4. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

2.3 ENCLOSURES

A. NEMA AB 1 and NEMA KS 1 to meet environmental conditions of installed location.

1. Outdoor Locations: NEMA 250, Type 3R; Type 4X where noted.
2. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
3. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Coordinate size and location of concrete bases. Verify structural requirements with structural engineer.

B. Concrete base is specified in Division 26 and concrete materials are specified in Division 03.

C. Comply with applicable portions of NECA 1, NEMA PB 1.1, and NEMA PB 2.1 for installation of enclosed switches and circuit breakers.

D. Mount individual wall-mounting switches and circuit breakers with tops at uniform height, unless otherwise indicated. Anchor floor-mounting switches to concrete base.

E. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

F. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.

G. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26.

3.2 FIELD QUALITY CONTROL

A. Prepare for acceptance testing as follows:

1. Inspect mechanical and electrical connections.

2. Verify switch and relay type and labeling verification.
3. Verify rating of installed fuses.

B. Perform the following field tests and inspections and prepare test reports:

1. Perform each electrical test and visual and mechanical inspection stated in NETA ATS, Section 7.5 for switches and Section 7.6 for molded-case circuit breakers. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

End of Section

SECTION 26 31 05

PHOTOVOLTAICS

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

ALTERNATE #1

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

B. The work herein is described as the responsibility of the Photovoltaic System Contractor (herein referred to as Contractor) selected to work on the photovoltaic system herein described. The Contractor must perform all of the tasks described in this and related Sections to provide a complete working Utility Interactive Photovoltaic System per these specifications.

C. Should any discrepancy or divergence occur in or between any of the Contract Documents as to the precise extent or nature of the work to be carried out by the Section 263105 PHOTOVOLTAICS (PV) Contractor, the Design Team and Owner shall immediately be notified so instruction may be given by the Design Team as to the work in fact required of the Section 263100 PV Contractor.

1.3 DESCRIPTION OF WORK

A. This section details the photovoltaic (PV) system to be bid, provided, installed, tested, turned on and warranted as defined herein

B. Work Included: Provide labor, tools, materials, equipment, and testing necessary to provide a complete and fully operational Solar Photovoltaic Power System including but not limited to the following:

1. Solar Photovoltaic Modules
2. DC-AC Power Inverters
3. Solar Array Mounting System
4. AC Combining Panelboards
5. AC Disconnects
6. PV System Transformer
7. PV System Service Meter

8. PV System Service Disconnect
9. DC and AC Wiring
10. Data Acquisition and Monitoring System

C. The installed photovoltaic (PV) system shall meet the following requirements:

1. The overall Solar PV system shall have a minimum DC nameplate rating of 774.90 kW.
2. The Inverter(s) shall have a total AC rating of 726.60 kW or as approved via submission.
3. The PV system shall be interconnected to the facility's electrical distribution system.

D. The Installation Contractor shall be certified by the North American Board of Certified Energy Practitioners (NABCEP) as a Professional PV System Installer.

E. Provide coordination drawings for approval of the inverter and associated Balance of System (BOS) component wall mounting scheme integration with architectural siding and structure.

F. Provide a job site training session and one (1) year of technical support for technicians or designated maintenance personnel at the facility.

G. Commission the system by performing initial startup of the system, verify proper DC and AC voltages, proper operation and communication capabilities of the PV system and DAS components, and coordinate to launch the manufacturers DAS page.

H. Recommission the PV array six (6) months after initial system acceptance.

I. Provide equipment labeling and a graphic plan directory in the main electrical room and at each location of PV system equipment that shows the location of all photovoltaic system disconnects as described in National Electric Code (NEC) Article 690.56.

J. Provide ten (10) extra photovoltaic modules as attic stock. Store attic stock in a location designated by Owner.

K. Provide ten (10) extras power optimizers as attic stock. Store optimizer attic stock alongside photovoltaic module attic stock.

L. Any deviations from the materials or methods described herein must receive written approval by the Design Team. Any work that is affected by these deviations becomes the responsibility of the Contractor.

M. Supply as-built electrical information to the Design Team in the form a revised drawing package submitted in *.pdf and/or *.dwg file format. As-built drawings should represent final conditions after acceptance of the installation and commissioning by all applicable parties. As-built drawings shall be prepared using a computer aided drafting software or other applicable software package. Handwritten documentation of as-built conditions should be avoided whenever possible.

N. All required permits, approvals and licenses required by Laws for the installation, use and operation of the Equipment, including without limitation, all federal, state and local building, and electrical permits shall be secured and paid for by the Contractor. The Contractor is responsible for payment of any permit or license fees. The equipment and the operation of the equipment by the Contractor shall conform to all federal, state and local code requirements. The Contractor shall furnish copies of each permit or license which is required to perform the work to the Owner before the Contractor commences the portion of the work requiring such permit or license.

1.4 REFERENCE STANDARDS

A. Underwriters Laboratories:

1. UL1703 Photovoltaic Modules
2. UL1741-SA DC-AC Inverters and Interconnection System Equipment
3. UL2703 Mounting Systems, Mounting Devices, Clamping/Retention Devices, and Ground Lugs for Use with Flat Plate Photovoltaic Modules and Panels

B. Institute of Electrical and Electronics Engineers:

1. IEEE 1547 Interconnecting. Distributed Resources with Electric Power Systems

C. National Fire Protection Association (NFPA) 70

D. National Electrical Code (NEC) – 2020 Edition or current version adopted by the Commonwealth

E. Massachusetts Electrical Code Amendments (MEC) – 2020 Edition or current version adopted by the Commonwealth

F. Refer to Paragraph, QUALIFICATIONS, in Section 260500, COMMON WORK RESULTS FOR ELECTRICAL.

1.5 QUALITY ASSURANCE

A. Refer to Section 011000 – GENERAL REQUIREMENTS for quality requirements.

B. Installing Contractor shall demonstrate that they have successfully installed at least three projects that, in aggregate, equal or exceed the size of the proposed project. References shall be provided for each of these referenced projects.

C. The mounting system for the solar photovoltaic array shall be engineered under the supervision of a licensed Professional Structural Engineer (PE) registered to practice in Massachusetts.

D. Provide evidence that the persons who are to perform the work herein have appropriate training or experience in similar PV system installations, and hold the proper licenses where applicable, prior to job execution.

E. Balance of System (BOS) equipment suppliers shall provide local representation when requested and shall have been actively engaged in the assembly, installation and service of proposed equipment for a period of not less than 3 years.

F. Equipment suppliers shall have full parts backup and service availability for this equipment.

G. The Contractor shall have the technical capabilities necessary to construct the PV system as designed, including programing of inverters and monitoring equipment as needed to meet the intent of the design for a fully functional system.

H. The Contractor shall be approved for installation of the PV system by the system providers, where required.

1.6 WARRANTY

A. Installer Warranty - The PV system must have a minimum 5 year labor warranty (from completion of the project) provided by the Contractor to protect the Owner against defective workmanship, PV panel or component breakdown (exceptions noted below), or degradation in electrical output of more than three percent from their originally rated electrical output during the warranty period. The warranty must cover the PV project, including PV modules, DC optimizers (if used), DC-AC inverters, the array mounting system, AC panelboards and data acquisition system and provide for no-cost repair or replacement of the PV project or system components, including any associated labor during the warranty period. Upon completion of the first year of the warranty, the performance and payment bonds will be released and the warranty will remain in effect by the Contractor for the additional four (4) years.

B. PV Modules - PV modules shall have a minimum 25 year power warranty and a 10 year product warranty, guaranteeing power rating at Standard Test Conditions will remain at 98% or greater than Minimum Specified Power Rating for the first five years and for the next twenty years guaranteeing a power rating at Standard Test Conditions will remain at 90% or greater than the Minimum Specified Power Rating.

C. Power Conditioning Equipment: The power conditioning equipment shall have a total 10-year (minimum) product warranty from date of sale to Owner with options to purchase a longer term warranty. During the warranty period, the manufacturer shall repair or replace the power conditioning unit (not including labor) and cover shipping charges incurred during shipment back to the Owner in cases of failure.

D. Mounting System - Manufacturer shall warrant the Array Mounting System to be free from defects in material and workmanship for a period of five (5) years, minimum.

E. Submit 2 original copies of Manufacturer’s Warrantees for all major system components. Contractor is to register all component warranties with the manufacturers of these components and provide documentation of such.

F. Present the Owner with service options for the system beyond the specified warranty period with a description of services provided and price.

1.7 WORKMANSHIP

A. All work under this Section shall be performed by skilled workmen regularly engaged and specializing in this type of work, in strict accordance with the installation directions of the approved manufacturers and as specified herein.

1.8 SUBMITTALS

A. Submittals shall comply with requirements of Section 011000 – General Requirements.

B. Contractor shall make all necessary field measurements and investigations to assure that the equipment and assemblies will meet contract requirements.

C. Product Data: For each major system component, submit manufacturer’s product description including physical dimensions and materials, electrical characteristics and specifications and statement of manufacturer’s warranties. Manufacturer equipment data sheets including sufficient data to indicate compliance with project specifications including weight, performance

data, and ratings for all associated PV system equipment. Clearly indicate which model is being selected. Indicate all options, special features, ratings and any deviations from this Section.

D. Submit shop drawings presenting the layout of the PV modules / arrays together with DC-AC inverters, as well as the AC panels, electrical disconnects and all other PV system equipment. Show all conduit runs with routing and destination, the location and type of all proposed penetrations and the location and proposed mounting of data acquisition system components.

E. If submittals present equipment configuration, placement, dimensions, or specifications different from that shown on the Contract Documents, provide drawings that show the rearrangement of all associated systems with justification for the proposed departure. Approval will be given only if all features of the equipment and associated systems, including accessibility, are equivalent to that required by the contract and acceptable to the Engineer of Record.

F. Submit an electrical single-line diagram of the overall PV system showing all components, their relationship with each other and their relative position. Provide details of interconnection of the PV system to the facility's electrical distribution system. Provide details of the Data Acquisition System installation and wiring and its interface with the facility and the internet.

G. If the installing contractor deviates from the basis of design provided, an updated, stamped single line and site plan shall be submitted to the utility. Any changes to the interconnection service agreement (ISA) due to system redesign shall be done at no cost to the client.

H. If the installing contractor deviates from the basis of design provided, the contractor shall submit updated PV calculations that demonstrate the selected system meets the performance requirements as stated herein. Calculations should include all assumptions, de-rating factors, peak power output in DC and AC and estimated monthly/annual kWh production.

I. Submit details of solar array mounting demonstrating that the array mounting system is compatible with the substructure.

J. Provide description of potential staging areas for materials during delivery and installation. Include coordination plan for delivery of materials to SITE.

K. Submit a complete Bill of Material listing all major components by quantity and part number.

L. Submit an itemized breakdown of pricing for components and services.

M. Provide the following submittals:

1. Proposed acceptance testing procedures
2. List of recommended spare parts to be kept in inventory on-site
3. List of spare parts to be provide by installation Contractor under this contract
4. O & M manuals – including training materials for Owner's personnel

N. Provide Owner with two hard copies and one electronic copy of Operation and Maintenance Manual with the following sections:

1. Safety precautions
2. Environmental conditions
3. Startup, shutdown, and post-shutdown procedures
4. Normal operations
5. DAS functionality
6. Emergency operations

7. Wiring and control diagrams
8. Preventive maintenance plan and schedule
9. Troubleshooting guides and diagnostic techniques
10. Maintenance and repair procedures
11. Recommended array cleaning protocol and frequency
12. Removal and replacement instructions
13. Testing equipment and special tool information

O. Submit final Design calculations and drawings of the structural support system for the PV modules. Structural Design calculations and drawings shall be sealed by a Professional Structural Engineer registered in Massachusetts confirming the completed system will withstand site wind loads as prescribed by Code. Alternatively the contractor may coordinate with the Design Team to provide the structural certifications.

P. If Contractor wishes to submit and any changes in the system design, the Contractor shall be responsible for all associated design and engineering and shall provide a narrative describing the proposed modifications supported by drawings and calculations, providing applicable professional engineering stamps registered in Massachusetts.

PART 2 - PRODUCTS

2.1 GENERAL PROVISIONS

A. Provide materials to install a complete and fully functional solar electric system in accordance with this Section, and all applicable codes and standards as set forth in the Contract Documents.

B. All materials shall be new and shall comply with the requirements of the specification.

2.2 MATERIALS

A. Photovoltaic Modules

1. Photovoltaic Modules shall consist of series-connected mono-crystalline silicon solar cells with integral bypass diodes between cell strings and shall have polarized, finger-safe, weatherproof, DC-rated, Multi-Contact (MC4) compatible plug-and-socket connectors. The cells shall be laminated between sheets of ethylene vinyl acetate and high-transmissivity tempered glass with anti-reflective (AR) coating and framed with a structural mounting frame of extruded aluminum.
2. Modules shall be UL listed, and shall have a UL Class B (minimum) fire rating. The highest efficiency modules available are the desired goal due to the limited space available. The Basis of Design Product is the SPR-A450-COM PV module from SunPower. One thousand seven hundred and eighty two (1,782) such modules have been included in the Basis of Design as installed and active modules. Any substitutions for the SunPower module must be approved by both the Owner and Design Team.
3. Once installed the PV modules are to be visually uniform and shall be subject to visual inspection for consistency. Replacement of unacceptable (as determined by the Design Team) PV modules is the responsibility of the Contractor.
4. A copy of the module flash test data shall be provided to the client and Design Team.

B. Inverters & Optimizers

1. DC-DC power optimizers are included in the basis of design to satisfy the rapid shutdown requirements of the NEC and to ensure optimal output of the PV array. The Basis of Design product is the P960 power optimizers as supplied by SolarEdge. Any substitutions for the P960 model must also have an accompanying proposed wire management scheme to be reviewed and approved by the Design Team.
2. DC-AC Inverters: PV Inverters shall be capable of complete automatic unattended operation including start-up, synchronization and disconnect, and operating in parallel with other inverters and the utility. Inverters shall be at minimum listed to UL1741 SA and compliant with IEEE 929 and 1547. The inverters shall be minimum 96% efficiency and compatible with the PV system array outputs as indicated on the Contract Drawings. The Basis of Design products are the SE20KUS, SE33.3KUS, and SE80KUS inverters as supplied by SolarEdge. Substitutes for the DC-AC inverter and optimizers are discouraged due to the complex physical nature of the array. Alternative equipment includes:
   a. Solectria PVI TL commercial inverters with Tigo Rapid Shutdown solution
   b. SMA Sunny CORE-1 commercial inverters with Tigo Rapid Shutdown solution
3. DC-AC inverters shall be rated NEMA 3R and be suitable for mounting outdoors.
4. Inverter communications shall be via RS485 Modbus cables with interface connector and software for diagnostics and data capture. Data logging communications shall be compatible for monitoring and recording data. The inverter and optimizer system shall be connected to the manufacturer's website for monitoring of the performance of the system components. The contractor is responsible for interfacing with the manufacturer to establish the project's website.
5. Inverter mounting structure shall be suitable for the environment where installed, consisting of hot dip galvanized steel and all fasteners being either hot-dip galvanized or stainless steel. The inverter mounting structure location shall be coordinated with the Client and MEP and shall utilize vibration-isolating anchors. Coordinate any changes with the architectural siding system and submit drawings of any deviations from the construction documents for review by the Design Team.

C. Mounting System

1. The solar array mounting system shall be of fixed tilt design with modules tilted at 10 degrees. The system shall be designed for a ballasted application and shall be listed to UL 2703.
2. Mounting system shall be designed specifically for the solar module chosen and shall be capable of supporting the quantity of modules in the configuration as shown on the Contract Documents.
3. Mounting system shall be aluminum or galvanized steel. Fasteners shall be stainless steel or hot dipped galvanized steel. All other hardware shall be galvanized steel or aluminum.
4. Basis of Design Product: Most of the roof is SunPower Helix Dual Tilt mounting system (Panelclaw clawFR Dual tilt), with the SolarDock Flat Roof Mounting Solution specified for the roof section which could not s.
5. Bidder is welcoming to propose and specify an alternative racking manufacturer, given that the racking can be supported by the roof's structural requirements.

D. AC Combining Panels

1. Combining panels shall be NEMA 3R rated and be suitable for outdoor mounting.

2. Panels shall provide individual circuit breakers for each inverter output circuit terminating within the unit and be rated for a minimum of 277/480 VAC 3-Phase.

3. Panel output terminals shall be rated both AL and CU cable termination. Basis of Design product shall be manufactured by Schneider Electric Square D, Eaton, or Siemens.

E. Data Acquisition System (DAS) & Metering

1. DAS shall comply with requirements of Section 263110 – PV DATA ACQUISITION SYSTEM.

F. Balance of System (BOS) equipment

1. AC disconnects: UL listed for the application and suitable for the environment in which installed. Only new equipment with the appropriate voltage and current ratings (as specified in the Contract Drawings) will be approved. If contractor's selects a different brand of disconnects than specified in the contract drawings, contractor shall provide a drawing showing a code-compliant solution in the space available for mounting them.
2. Utility meter socket: UL listed for the application and suitable for the environment in which installed. Only new equipment with the appropriate voltage and current ratings (as specified in the Contract Drawings) will be approved. Revenue grade NET meter to be provided by Utility for the building service.
3. Building Penetrations: Any/all penetrations for the racking systems and conduit shall be coordinated and approved by the Project Team.
4. Building Anchors: All areas of securement, methods of waterproofing, and physical attachment shall be coordinated with and approved by the Project Team.
5. Electrical panels: UL listed for the application and suitable for the environment in which installed. Only new equipment with the appropriate voltage and current ratings (as specified in the Contract Drawings) will be approved.
6. PV System Transformer: UL listed for the application and suitable for the environment where installed. Only new equipment with the appropriate voltage, kVA, and topology specifications (as specified in the Contract Drawings) will be approved.
7. Wireways and troughs: UL listed for the application and suitable for the environment in which installed with appropriate NEMA ratings. Physical partitions between AC and DC conductors in the same raceway shall be installed per NEC 690.31.
8. Transient voltage surge suppression: Grounding, lightning arrestors and surge suppressors shall be provided as required to protect the solar and building electrical equipment, and as indicated in the Contract Drawings.
9. DC wiring: Homerun wiring under the modules shall be supported above the surface of the building, mountable to the racking structure or contained within a cable tray as required to provide wire management from the PV module source circuits to transition boxes. Plastic wire ties shall not be permitted to be the primary wire management strategy for the project.
10. Conduit: All outdoor, exposed, and high traffic area conduits shall be rigid galvanized steel, RMC or IMC. All interior conduit shall be electrical metallic tubing (EMT) or as specified on the Contract Drawings.
11. Wire: UL Listed, new, copper unless otherwise noted, and of the correct type, continuous for each wiring run. Insulation shall have a 1000V rating where required for the system voltage, and a 600V rating otherwise. The following additional requirements apply.
    a. In areas where the conductors may be subjected to high temperatures such as in exposed conduits or mechanical rooms the insulation rating shall be rated 90º C. Other areas shall use insulation rated for a minimum of 75ºC.

b. Any wire that is exposed to sunlight shall be UL recognized as sunlight resistant and labeled as such.
c. Conductors #12 and larger shall be stranded.
d. Conductor splices and terminations must be UL listed.

12. Labels: All Balance of System equipment shall be appropriately identified and labeled as indicated in the Contract Drawings and the NEC with permanent, self-adhesive, engraved red stock with white core plastic with a minimum thickness 1/16" or an approved equal. Lettering shall be standard engraver's letter style using a standard size appropriate for the application in accordance with the NEC.

PART 3 - EXECUTION

3.1 DELIVERY, STORAGE AND HANDLING

A. PV modules and system components shall be delivered to their final locations in protective wrappings, containers, and other protection that will exclude dirt and moisture and will prevent damage from construction operations. Protection will be removed only after equipment is safe from such hazards. Each module or other equipment shall be visually inspected for defects by the Contractor upon receipt. The Contractor shall make suitable arrangements for safe on-site storage of all solar components and materials and shall be responsible for the safe keeping of all solar system components until the system has been accepted by the Owner.

B. Do not store any modules upside-down at the top of the pallet, where the frame and backsheet can fill with water. If the supplier packed any pallets in this manner, provide protection to keep water from accumulating inside any module.

C. Partial pallets of modules shall be secured via ratchet straps to prevent module displacement due to high winds. Each time the ratchet strap is used, provide protection to prevent the ratchet assembly from scratching any surface of the modules, including the aluminum frames. All other materials shall be properly secured with ratchet straps or appropriate temporary ballasting to prevent displacement from wind. Contractor shall protect the area from damage due to any stray nails that the pallets may contain, as pallets of materials are placed upon the site during construction. The recommended solution is to place landing pads beneath each pallet, made from Styrofoam-backed plywood.

3.2 INSTALLATION

A. The PV project shall be installed according to the manufacturer's instructions**.** The installed system must be in compliance with all the applicable codes and standards including:

1. Local, state, and/or federal building and electrical laws, codes and practices. The provisions of the appropriate version of the Massachusetts Electric Code (MEC) amendments as specified current code version that has been adopted by the Commonwealth.
2. The interconnection agreement has been filed with the utility and is awaiting approval.
3. Installation Contractor is responsible for obtaining all permits and must keep copies on the jobsite in a readily visible location as required by state law. City of Cambridge permit(s) will be provided without charge: see Division 1 of this specification.

B. The Installation Contractor shall be responsible for ensuring the proper installation of all solar system components, wiring, conduits, panels, instrumentation as described in the Contract Documents and supported by the submitted shop drawings. All manufacturer's guidelines shall

be followed during installation of the system. All mechanical and electrical fasteners shall be torqued to manufacturer's specifications. All wiring not enclosed in conduit shall be properly restrained in keeping with established wire management procedures to avoid chaffing on exposed metal parts.

C. The Contractor shall work with the manufacturer's representative to ensure that the Data Acquisition System is properly programed and fully operational prior to initial system start-up.

D. Ensure that all disconnects are in the OPEN position and all fuses are removed from the source circuit combiners prior to installation and remain so until acceptance testing is completed.

E. Prior to installing the PV array, clean the area of any debris or dirt and inspect the area to ensure that the installation is complete and that there is no debris or conditions that could lead to damage to the area when the PV array is installed.

F. The installation crew is to have a minimum of one licensed electrician who has documented experience installing utility interconnected photovoltaic systems and is NABCEP certified.

G. All building penetrations shall be sealed and protected with fire-rated material in compliance with all applicable building codes.

H. Install all wiring in a neat and workmanlike manner. Wires shall be looped for strain relief and secured with metal wire clips to module frames. Wires shall be supported above the surface without slack loops.

I. Protect module connectors from the environment with connector caps from the connector manufacturer, during all unattended hours.

3.3 LABELING AND IDENTIFICATION

A. All array strings shall be uniquely tagged and identified with a record kept and provided to the Owner's personnel to facilitate future diagnostic and troubleshooting purposes.

B. Supply and properly affix contrasting plastic engraved labels to identify all equipment and also satisfy all NEC labeling requirements regarding electrical hazard and personnel safety.

C. Supply and properly affix arc flash labeling to all applicable pieces of equipment. Contractor to complete or obtain the necessary arc flash calculations to properly fill out arc flash labeling.

D. Maintain a record of the layout of module level power electronics during installation for the SolarEdge monitoring portal, to assist with future diagnostics. Contractor shall set up the monitoring portal and implement the physical layout of optimizers and string assignments. Provide a public link, and an account for the end-user.

3.4 PRE-COMMISSIONING INSPECTION

A. The Contractor shall perform the following inspection in advance of the independent 3rd party commissioning of the system:

1. Physically inspect the tightness of all wiring terminations and re-torque as necessary.
2. Physically inspect all exposed wiring to ensure it is properly restrained and cannot chafe on exposed metal parts.

3. Physically inspect all PV modules' quick-connects to ensure they are properly seated.
4. Physically inspect and verify all modules are clean and free from damage.
5. Physically inspect and verify all wire terminations, enclosures and equipment to ensure they are clean, properly labeled and free from damage.
6. Physically verify circuit breakers are suitable for back-feed in accordance with the MEC.
7. Verify all excess sealants, filings, grease, tape residue, dust, and debris are removed from system components.
8. Curve tracing is not required with the module level power electronics specified as the basis of design. If the contractor substitutes string or central inverters into the design, curve tracing of all source circuits will be required. Additional infra-red scanning of the array may be needed to find the source of problems revealed in curve tracing.

3.5 INSPECTION AND STARTUP

A. Conduct testing as outlined in the following sub-sections on the PV system to verify compliance with all requirements of this specification. Tests shall be conducted after the PV system has been installed, and after all electrical and mechanical connections have been made. Results of all tests shall be documented and archived for future reference. Copies of all test documentation are to be provided in the Operation and Maintenance Manual as described herein. Be prepared at any time during the startup process to remedy any portions of the system that do not perform to the manufacturer's operating specifications or that fail to operate due to poor workmanship.

B. The PV system is not accepted until the Utility provides a written statement of acceptance.

C. Notify the Design Team in writing when the PV system is completely installed with preliminary field testing complete.

D. Conduct an in-depth inspection to ensure that the PV system is installed in a workmanlike manner and is consistent with industry practice and operational requirements. A photo record of the installation and major components, including PV modules, inverters, and BOS and is to be made. Include photos showing connections within all installed enclosures. Provide a copy of the record in the Operation and Maintenance Manual described herein.

E. Verify proper torque settings of electrical and mechanical connections.

F. Verify that all outdoor components are weatherproof and capable of surviving intact under the site environmental conditions. Check that all outdoor enclosures are equipped to alleviate condensation. Check that all doors, covers, panels, and cable exits are gasketed or otherwise designed to limit the entrance of dirt and moisture.

G. Ensure that all wiring is supported as required and that proper strain relief is correctly installed. Inspect that all exposed wiring is of the correct type and suitably sunlight and weather resistant and is factory marked (stamped) as such. Inspect that all wires have identifying labels or markings on both ends. The labels or markings shall be permanent and durable. Labels or markings on exposed wiring shall be of type that is rated for withstanding the outdoor environment. Inspect that wiring is bundled, laced and otherwise laid in an orderly manner.

H. Verify that all non-current-carrying metal parts are solidly grounded and all equipment and PV system grounding is installed and functional per NEC 250.

I. Confirm that all lightning arrestors and surge suppressors are properly installed and wired.

J. Inspect PV module surfaces for cracks or discolorations. Note the build-up of any debris on or around PV arrays, especially under and around the system hardware.

K. Verify that exposed wiring is of the correct type and suitably sunlight and weather resistant and is factory marked (stamped) as such.

L. Check wires for permanent and durable identifying labels or markings on both ends.
Confirm that wiring is bundled, laced and otherwise laid in an orderly manner. Make sure that the wires that land on the inverter(s) or DC combiners (when used) are identified with permanent and durable labels per their unique source circuit ID number, polarity, inverter & input section, number of modules within the source circuit and/or any other identifying marking called out on the contract drawings.

M. Inspect all electrical components. Test the inverters as outlined in the inverter's Operations and Maintenance manual.

N. Confirm that the Data Acquisition System is functioning properly.

O. Coordinate with the Design Team, Owner, and Utility to address questions, comments or concerns prior to closeout.

3.6 INVERTER OPERATIONAL TESTS

A. In addition to the following test sequence the Contractor shall perform all tests required by the Manufacturer as outlined in the inverter's Installation and Operator's Manual.

1. Be sure that inverters are switched off before proceeding.
2. Test and record the AC line voltage at the inverters to ensure that it is within the proper limits as stated by the manufacturer.
3. Test that the phase sequencing is correct, if applicable.
4. Check the continuity of all fuses.
5. Check that the DC open-circuit voltage is within the manufacturer's recommended range at the DC disconnects.
6. If the DC voltage is correct, close the inverter cover and close the DC and AC disconnect switches.
7. After manufacturer's specified start up time (five min.), confirm that the inverter is operating by recording the DC operating voltage and currents, AC phase voltages and phase currents and inverter power.
8. Close all open equipment enclosures.
9. Look and listen for, find the cause, and remedy anything unusual from the PV array or BOS components.

B. Additional testing shall demonstrate proper functional operation of control and protective features under normal and abnormal conditions. In some cases, devices external to the inverters can handle one or more of these features.

C. Confirm Wake-Up and Sleep Separations.

D. Check Loss of Utility and loss of Array.

E. Turn on the PV system and verify that it is working as specified. After manual start-up, witness and record proper system operation under automatic start-up, full power operation and automatic nighttime shutdown. Record all operating parameters of the PV system during this period.

1. Include a copy of the start-up test report in the Operation and Maintenance Manual defined herein.

3.7 POST-START UP TESTS

A. Perform IR testing of all connections and panels once the array is in operation. Provide again 6 months after completion.

3.8 UTILITY APPROVAL

A. Once system commissioning is completed and all remedial work has been addressed, the installation Contractor shall contact the utility to request permission to operate the system. The utility may want to make a field inspection of the system. The installing contractor shall be present for any utility inspections.

B. The utility may also request to be present during the witness testing of the protective relaying and on-site system as a requirement for utility interconnection and operational approval of the solar plant. If desired, SDA can participate in the witness testing by the utility field engineers prior to formal system acceptance.

3.9 DOCUMENTATION

A. Contractor will prepare Operating and Maintenance Manual in hard cover binder and deliver to Owner. As a minimum the manual shall include:

1. As-built plans showing the final placement of all panels, connections and conduit.
2. As-built electrical plans, including single line diagrams.
3. A complete set of all approved submittals including shop drawings and product literature.
4. Troubleshooting guidelines
5. System maintenance schedule and procedures.
6. Contact information for technical assistance and parts ordering.
7. Provide a list of recommended spare parts and their sources and deliver the spare parts inventory agreed upon to the Owner.

3.10 TRAINING OF OWNER'S PERSONNEL

A. Prior to final project close-out and system acceptance by the Owner, the installation contractor shall host and conduct a one-day training session for the Owner's personnel on the operation and maintenance of the solar system. See additional training requirements in Division 1

End of Section

SECTION 26 31 10

PHOTOVOLTAICS DATA ACQUISITION SYSTEM

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

ALTERNATE #1

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

B. Equality of material, article, assembly or system other than those named or described in this Section shall be determined in accordance with the provisions of Article V of the CONTRACT AND GENERAL CONDITIONS.

C. Examine Drawings and other Sections of the Specifications for requirements therein affecting the work of this Section.

D. Coordinate work with that of other trades affecting or affected by work of this Section. Cooperate with such trades to assure the steady progress of all work under the Contract.

E. The work herein is described as the responsibility of the Photovoltaic System Contractor (herein referred to as Contractor) selected to work on the photovoltaic system herein described. The Contractor must perform all of the tasks described in this and related Sections to provide a complete working Data Acquisition System (DAS) per these specifications.

F. Should any discrepancy or divergence occur in or between any of the Contract Documents as to the precise extent or nature of the work to be carried out by the Section 263110 PHOTOVOLTAIC (PV) DATA ACQUISISTION SYSTEM (DAS) Contractor, the Design Team and Owner shall immediately be notified so that the Team's direction or instruction may be given as to the work in fact required of the Section 263110 DAS Contractor.

1.3 DESCRIPTION OF WORK

A. This Section details the DAS to be provided, installed, tested, turned on and warranted as defined herein. The PV system design specifications, hardware and details are defined in Section 263105 PHOTOVOLTAICS and on the Contract Drawings.

B. Provide all labor, instrument procurement, tools and equipment necessary for installation of a complete and operational DAS as indicated on the Contract Drawings and specified herein.

C. The DAS shall perform data acquisition on the PV systems for this project, as specified herein and in the Contract Drawings.

D. Provide on-site training and long-term technical support on the DAS (1 yr.) for the installers and the technicians or designated maintenance personnel at the facility.

E. Provide data hosting for a period of 10 years that allows internet access to the instantaneous and archived data as it is collected by the DAS. The archived data shall be time frame and parameter selectable in both graphical on-screen display and tabular comma-separated value (CSV) format. Present the Owner with options for extending the DAS hosting period beyond the specified hosting period with a description of services provided and price.

F. Any deviations from the materials or methods described herein must receive written approval by the Design Team. Any work that is affected by these deviations becomes the responsibility of the Contractor.

G. Supply and install data acquisition equipment. Coordinate the installation of enclosures with the 263105 Photovoltaic Contractor.

H. The Contractor is responsible for setting up the revenue grade metering agency reporting account. Contractor is to provide the owner with all required documentation for the agency reporting account.

1.4 QUALITY ASSURANCE

A. The data logger equipment manufacturer shall be a company specializing in the manufacture of data acquisition equipment and have at least 3 years of documented experience with their hardware in commercial applications in the field.

B. Data acquisition instrumentation manufacturers shall have been actively engaged in the assembly and service of this equipment for a period of not fewer than 3 years.

C. Installer shall have the technical capabilities necessary to program and coordinate the DAS equipment with the solar and facility equipment.

D. All equipment suppliers shall have full parts backup and service availability for their supplied equipment.

E. All material supplied for this project shall be new.

1.5 WARRANTIES

A. Provide the Owner with a full five (5) year warranty on the entire DAS and all of its materials, components, equipment and labor. This warranty shall provide for service at the site including the repair and / or replacement of components found to be defective within the warranty period. The Contractor may include pass-through warranties from the manufacturers of major DAS components. However, it will be the responsibility of the Contractor to provide initial trouble shooting of the DAS and to obtain service/support by the manufacturers under their warranties as appropriate to minimize system downtime and maintain operability. This warranty will start following acceptance of the fully operational DAS by the Owner.

B. Present the Owner with service options for the DAS beyond the specified warranty period with a description of services provided and price.

1.6 WORKMANSHIP

A. All work under this Section shall be performed by skilled workmen regularly engaged and specializing in data wiring, in strict accordance with the installation directions of the approved manufacturers and as specified herein.

1.7 SUBMITTALS

A. Provide submittals on all products needed for the work delineated herein to the Design Team within fifteen days after notice to proceed.

B. Provide a complete, scaled shop drawing or system description, describing all DAS components and accessories being provided or required for operation as specified herein. Include the locations of all DAS related building penetrations and DAS related equipment.

C. Furnish technical specifications for all of the DAS components.

D. Furnish technical specifications on all types of data acquisition signal wires proposed for use, as described herein and in the Contract Drawings.

E. Furnish one example of the charts and reports specified in Section 2.1.

1.8 APPLICABLE CODES AND STANDARDS

A. UL Standards

1. All products shall be UL listed.

B. NFPA Standards

1. NFPA 70 National Electrical Code.

C. ANSI Standards

1. ANSI C12.16 Code for Electricity Metering.

D. Additional Standards

1. Local and State Codes and all local authorities having jurisdiction.
2. All applicable referenced standards in related sections.
3. Sunspec Alliance standards or approved equal for communication and equipment interoperability.

PART 2 - PRODUCTS

2.1 MANUFACTURER

A. Ap[proved Manufacturers:

1. PowerDash.

B. The Data Acquisition and Monitoring System shall be integrated into the City of Worcester existing PowerDash data acquisition and monitoring infrastructure.

C. The Vendor will provide all necessary hardware as well as software to facilitate the integration per the City's requirements.

D. The Data Acquisition and Monitoring System (DAS) shall allow the owner to monitor and utilize the collected data for educational purposes over the school network.

2.2 DATA ACQUISITION SYSTEM (DAS)

A. Provide all data acquisition equipment required for a complete and working DAS. The DAS equipment shall be capable of collecting and recording the measured parameters indicated herein, and provide secure access from remote computers outside the facility's local area network (LAN). The DAS provider shall host the collected data and make it accessible to approved users via the internet in the formats defined herein for a period of not less than ten (10) years.

B. All equipment shall be compliant with SunSpec Alliance requirements or approved equivalent for communication and interoperability.

C. All enclosures shall have NEMA rating appropriate for the environment in which they are to be installed.

D. Coordinate the supply of a dedicated internet connection for the DAS, to be provided by the Owner. Provisions for the local internet service to the data logger are not the responsibility of the Contractor.

E. The DAS shall include all of the sensors and wiring required to measure the parameters listed herein.

F. The DAS shall include a weather station mounted at the array consisting of (at a minimum), an irradiance sensor and a module temperature sensor as specified herein and mounted as indicated in the Contract Drawings. The DAS shall include all of the sensors, wiring, and logging devices required to measure and report the parameters listed herein.

G. The DAS shall perform the following tasks:

1. Sample the listed parameters data at least 1 time per minute and log 15-minute (minimum) average records to the data storage area.
2. Retain logged data upon loss of power.
3. Start logging data and re-establish network connections automatically when power is restored.
4. Generate daily and monthly files as defined herein.
5. Store the logged data for a minimum period of 10 years.

H. The following parameters shall be monitored.

1. Plane-of-array irradiance (W/m2) shall be measured with a reference cell
2. Module temperature (˚C) shall be measured with an adhered sensor, attached to the back of a single module, centered beneath an individual cell.

3. Instantaneous (kW) and accumulated (kWh) power output for each of the PV systems in the project shall be measured with a utility grade revenue meter.

I. A daily file shall be generated by the DAS that shall include, at a minimum, 15-minute averaged data over the entire day for each of the parameters listed above and be available in a tabular CSV format.

J. Provide a web page, hosted by the system vendor, which displays the real time data that is broadcast by the DAS equipment and updated at least every fifteen minutes.

K. Provide web hosting of the monitoring data and website for a minimum of 10 years.

L. The real time web page display shall include, at a minimum, in a graphical format, the following:

1. The instantaneous irradiance as measured by the reference cell.
2. The instantaneous module temperature.
3. The instantaneous AC power being produced by the PV system with a revenue grade quality kWh meter.
4. The total daily electrical energy harvest produced by the PV systems as a running sum.
5. The total year-to-date electrical energy harvest produced by the PV systems as a running sum.
6. The total lifetime electrical energy harvest produced by the PV systems as a running sum.
7. The aggregate amount of CO2 abated by the use of the PV systems as a running total.

M. Archive and host the Daily 15 minute average data described herein for a minimum period of ten (10) years. The data hosting shall allow access from the supplied web page to archived data provided by the DAS. Access to the data shall be selectable by user defined time periods and available in both a graphical and tabular format.

N. Provide mounting hardware for the data logger and associated equipment as required.

O. Contractor to provide network connection as required.

P. All weather instrumentation shall be mounted with hardware designed for such purpose.

Q. All exposed wiring, including weather instrumentation sensor leads, is to be made with sunlight resistant wire.

R. Data acquisition enclosures shall be appropriately identified with permanent, self-adhesive, engraved red stock with white core plastic with a minimum thickness of the 1/16”. Lettering shall be standard engraver’s letter style using a standard size appropriate for the application in accordance with the NEC.

PART 3 - EXECUTION

3.1 PRE-INSTALLATION CONFERENCE

A. Pre-installation Conference: Before installation of the DAS begins, conduct a pre-installation conference with the installers, and other interested parties to review procedures, schedules, safety and coordination of the installation with other elements of the Work.

3.2 GENERAL

A. Instruct relevant technicians in correct installation of the data acquisition system as shown on the Contract Drawings, in full compliance as indicated in all of the various system components manufacturer's instructions and as required for neat, workmanlike and fully integrated and operational systems. Ensure that all code required and recommended clearances are maintained.

B. Ensure that all disconnects are in the OPEN position prior to installation and remain so until installation is completed.

C. Advise installation personnel that PV modules generate lethal voltage when exposed to sunlight. Care must be taken when wiring the data acquisition system to the PV system to avoid electrical shock. 'Live wiring methods' should be employed.

D. Read and understand all drawings and manuals prior to installation. Be advised to have all component switches in the OFF position.

E. All building penetrations shall be sealed and protected with the specified fire rated material.

3.3 WIRING

A. Wire: UL Listed new, copper, of the correct type and continuous for each wiring run. Insulation shall have a 600V rating in most circuits, and a 1000V rating where required for voltages exceeding 600V.

B. In areas where the conductors may be subjected to high temperatures, such as in exposed conduits on the exterior of the building or mechanical rooms, the insulation rating shall be rated 90º C. Other areas may use insulation rated 75ºC.

C. Any wire that is exposed to sunlight shall be UL recognized as sunlight resistant and labeled as such.

D. Conductors larger than #12 shall be stranded.

E. Wiring shall be continuous for each wiring run.

F. Conductor splices and terminations must be UL listed.

3.4 CLEANING

A. Remove all excess sealants, filings, grease, tape residue, dust and debris from the entire DAS system.

B. Work shall be protected from damage from other trades.

C. Ensure the site is clean and secure, in a workmanlike condition, for the duration of, and at the completion of, the project.

3.5 INSPECTIONS AND STARTUP TESTING

A. After the complete data acquisition system has been installed, all electrical and mechanical connections have been made, all of the deliverables have been submitted, and the PV system is up and running, the Contractor will conduct the initial Startup Tests (below) on the entire DAS system to verify compliance with all requirements of this specification.

3.6 PRE-STARTUP TESTS

A. Before start-up of the DAS can take place, testing as outlined below shall be completed satisfactorily.

B. Conduct an in-depth inspection to ensure that the data acquisition system is installed in a workmanlike manner and consistent with industry practice and operational requirements and is as specified on the Contract Drawings. A photo record of all instruments and terminal blocks is to be made by the Contractor after they are installed and wired. A copy of this record is to be included in the Operation and Maintenance manual defined herein.

C. Verify that all instruments are new and are installed properly.

D. Inspect that all outdoor components are weatherproof and capable of surviving intact under the site environmental conditions. Check that all outdoor enclosures are equipped to alleviate condensation and that all doors, covers, panels, and cable entries/exits are gasketed or otherwise designed to limit the entrance of dirt and moisture.

E. Inspect that all wiring is new, is as specified on the contract drawings, and continuous for each wiring run; splices are not acceptable. Ensure that all wiring is well supported and that proper strain relief is installed. Confirm that all exposed wiring shall be suitably sunlight and weather resistant and shall be factory marked (stamped) as such. Confirm that wires have identifying labels or markings on both ends. The labels or markings shall be permanent and durable, and when on exposed wiring shall be of a type that is rated for withstanding the outdoor environment. Confirm that wiring is bundled, laced and otherwise laid in an orderly manner.

3.7 STARTUP TESTS

A. The following tests must be made before the system is deemed complete.

1. Confirm that the data acquisition system reads zero for all the measurements when the respective instruments are turned off.
2. Verify and record that all the measurements are reading in the proper range when the respective instruments are turned on. Include a copy of the test results in the Operation and Maintenance manual described herein.
3. Verify that all the files created by the data acquisition system are in the proper format and have valid values.
4. Verify that the data is being displayed properly on the web page.
5. Confirm that all links to the real time and archived data are working properly.
6. Confirm that the data files are retained upon loss of power.
7. Confirm that the daily and monthly files are being generated properly.
8. Confirm that the data acquisition system starts automatically and re-establishes network connections upon restoration of power.
9. Confirm that the hosting organization is receiving the files and that the owner is in receipt of all relevant account documentation.

10. Confirm that the revenue grade meter and associated system components have been set up properly and that the agency reporting account information is correct and functional.

3.8 OPERATION AND MAINTENANCE MANUAL

A. Provide a complete operation and maintenance manual for the entire data acquisition system (3 printed copies and one electronic copy of the entire manual on USB flash drive).

B. Manuals are to incorporate

1. As-built electrical drawings
2. Product cut sheets
3. Maintenance schedules and procedures
4. Installing Contractor and equipment manufacturer's contact information
5. Serial numbers of all equipment
6. A photo record of the installation including close ups of all enclosures with the covers open
7. Complete system description describing all operating parameters required, including but not limited to the IP address of data logger, and any required login information for each piece of equipment in the system.
8. Warranty and calibration information on all of the components
9. As-built shop drawings
10. A copy of the required submittals
11. A copy of the files generated during system testing.

3.9 OPERATION

A. Leave the DAS in operating condition.

End of Section

Section 26 32 13

ENGINE GENERATORS

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. 1000kW/1250kVA, emergency/standby power system to supply electrical power at 480/277 Volts, 60 Hertz, 3 Phase. The generator shall consist of a liquid cooled diesel engine, a synchronous AC alternator, and system controls with all necessary accessories for a complete operating system, including but not limited to the items as specified hereinafter.

1.4 REQUIREMENTS OF REGULATORY AGENCIES

A. An electric generating system, consisting of a prime mover, generator, governor, coupling and all controls, must have been tested, as a complete unit, on a representative engineering prototype model of the equipment to be sold.

B. The generator set must conform to applicable NFPA requirements.

C. The generator set must include a listing for the UL2200 standard for stationary engine generator assembly.

D. The generator set must meet EPA federal emission guidelines for stationary emergency power generation.

1.5 MANUFACTURER QUALIFICATIONS

A. This system shall be supplied by an original equipment manufacturer (OEM) who has been regularly engaged in the production of engine-alternator sets, automatic transfer switches, and associated controls for a minimum of 25 years, thereby identifying one source of supply and responsibility. Approved suppliers are Generac Industrial Power or an approved equal.

B. The manufacturer shall have printed literature and brochures describing the standard series specified, not a one of a kind fabrication.

C. Manufacturer's authorized service representative shall meet the following criteria:

1. Certified, factory trained, industrial generator technicians.
2. Service support 24/7.
3. Service location within 200 miles.
4. Response time of 4 hours.
5. Service & repair parts in-stock at performance level of 95%.

1.6 SUBMITTALS

A. Product Data: For each type of packaged engine generator and accessory indicated.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

C. Manufacturer Seismic Qualification Certification: Submit certification that engine-generator set, batteries, battery racks, accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
   b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Source quality-control test reports.

E. Field quality-control test reports.

F. Operation and maintenance data.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.

B. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 200 miles (321 km) of Project site, a service center capable of providing training, parts, and emergency maintenance repairs.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. Comply with ASME B15.1.

E. Comply with NFPA 37.

F. Comply with NFPA 70.

G. Comply with NFPA 110.

H. Comply with UL 2200.

I. Engine Exhaust Emissions: Comply with applicable state and local government requirements.

J. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at adjacent property boundaries due to sound emitted by generator set including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

1.8 PROJECT CONDITIONS

A. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient Temperature: Minus 15 to plus 40 deg C.

2. Relative Humidity: 0 to 95 percent.
3. Altitude: Sea level to 1000 feet (300 m).

1.9 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers

1. Caterpillar; Engine Division.
2. Generac.
3. Kohler Co.; Generator Division.
4. Or approved equal.

2.2 ENGINE-GENERATOR SET

A. Factory-assembled and -tested, engine-generator set.

B. Mounting Frame: Maintain alignment of mounted components without depending on concrete foundation; and have lifting attachments.

C. Capacities and Characteristics:

1. Power Output Ratings: Nominal ratings as indicated on the drawings.

2. Output Connections: Three-phase, four wire.

3. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.

D. Generator-Set Performance:

1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.

2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.

3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.

4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.

5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.

6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.

7. Sustained Short-Circuit Current: For a 3-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.

8. Below requires 10-second maximum start time under specific conditions and includes startup only, not load assumption.

9. Start Time: Comply with NFPA 110, Type 10, system requirements.

2.3 ENGINE

A. Fuel: Fuel oil, Grade DF-2.

B. Rated Engine Speed: 1800 rpm.

C. Maximum Piston Speed for Four-Cycle Engines: 2250 fpm (11.4 m/s).

D. Lubrication System: The following items are mounted on engine or skid:

1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.

2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.

3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

E. Engine Fuel System:

1. Main Fuel Pump: Mounted on engine. Pump ensures adequate primary fuel flow under starting and load conditions.

2. Relief-Bypass Valve: Automatically regulates pressure in fuel line and returns excess fuel to source.

F. Coolant Jacket Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity.

G. Governor: Adjustable isochronous, with speed sensing.

H. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine-generator-set mounting frame and integral engine-driven coolant pump.

1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.

2. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.

I. Muffler/Silencer: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

1. Minimum sound attenuation of 25 dB at 500 Hz.

2. Sound level measured at a distance of 10 feet (3 m) from exhaust discharge after installation is complete shall be 85 dBA or less.

J. Air-Intake Filter: Heavy-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

K. Starting System: 24-V electric, with negative ground.

1. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.

2. Cranking Cycle: As required by NFPA 110 for system level specified.

3. Battery: Adequate capacity within ambient temperature range specified in Part 1 "Project Conditions" Article to provide specified cranking cycle at least twice without recharging.

4. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35-A minimum continuous rating.

a. Battery Charger: Current-limiting, automatic-equalizing and float-charging type. Unit shall comply with UL 1236.

2.4 FUEL OIL STORAGE

A. Comply with NFPA 30.

B. Base-Mounted Fuel Oil Tank: Factory installed and piped, complying with UL 142 fuel oil tank. Features include the following:

1. Tank level indicator.
2. Capacity: Minimum 3600 gallons.
3. Vandal-resistant fill cap.
4. Containment Provisions: Fuel Oil Storage Tanks are to be double wall and dual containment type.

2.5 AUTOMATED FUEL FILTRATION SYSTEM

A. Description: Stand-alone, factory complete, automated, programmable, Green Clean Institute Certified, fuel filtration, optimization and maintenance system shall be provided for each diesel fuel storage tank to optimize and maintain the condition of fuel stored in that tank. The system shall be capable of eliminating microbial contamination and removing water, sediment and particulate to comply with ASTM D975 (Standard Specification for diesel Fuel Oils).

1. Enclosure: All system components shall be contained within a powder coated or stainless steel, weatherproof, outdoor NEMA / UL 50 Type 4 listed enclosure with appropriate ventilation. Hinged front door shall be equipped with quarter-turn key lockable handle. Fluid containment area with leak detection shall be an integral component of the enclosure. Literature pocket inside enclosure and external enclosure brackets for wall or rack mounting to be included.
2. Plumbing: Components shall be located within the enclosure. Internal plumbing will be primarily executed in stainless steel.
3. Installation: System shall provide male pipe connections protruding from the enclosure for customer plumbing connection. System shall be located as close as possible to designated fuel tank. The system's fuel supply and discharge lines shall be independent and separate from other fuel lines, with the supply line originating at the lowest point at the bottom of the tank and the discharge line as far away as possible from the supply line.
4. Filtration / water separation: Three stage filtration / water separation process:
    a. Stage 1: Centrifugal water and coalescing particulate separation – with water detection sensor and "push and turn" safety drain valve.
    b. Stage 2: Fuel Conditioner – to reduce the size and mass of fuel sediments which naturally form in fuel.
    c. Stage 3: Secondary Filtration – Uses a spin-on filter element. Elements shall be available with particulate filtration of 1 micron and dissolved and emulsified water absorbing "WB water block" filtration of 3 microns.
    d. Filter / Water Separator shall be equipped with a liquid-filled compound vacuum/pressure gauge.
5. Water Sensor: Microcontroller-based water sensor alarm module to eliminate probe corrosion.
6. Controls / Display functions: System control features and indicator lights shall be located on the display panel of the Smart Filtration Controller for easy operator access. A stack light beacon shall be located on the top of the enclosure to provide an external indication of a system alarm condition as listed below. Additional alarm and system status information shall be displayed on the PLC text screen. System shall provide the following control and display functions via a PLC controller:

a. Programmable digital timer – Memory backup to retain program memory during power outages

b. Pump operating hour counter

c. Pump control switch (Auto-Off-Manual) - Key operated, on the display panel of the Smart Filtration Controller

d. Power available indicator - Green LED indicator light, on the display panel of the Smart Filtration Controller

e. Pump running indicator - Amber LED indicator light, on the display panel of the Smart Filtration Controller

f. Alarm indicator - Red LED indicator light for high vacuum, high pressure, high water level in filter bowl, and leak detection alarms - on the display panel of the Smart Filtration Controller

g. Alarm reset push button - on the display panel of the Smart Filtration Controller

7. Electrical enclosure / Controller: All electrical control features shall be contained within a separate UL 508A listed industrial control panel located within the mechanical enclosure. The controller shall monitor the following system alarm conditions:

a. Leak in enclosure (system shutdown)

b. Primary Filter/Water Separator high vacuum (system shutdown)

c. Primary Filter/Water Separator high water level (system shutdown)

d. Secondary filter high pressure (system shutdown)

e. External system shut down input

8. Pump: Positive displacement, internal gear, direct coupled, rotary pump with cast iron housing and built-in pressure relief bypass valve. Pump flow rate of 2.5 gallons per minute.

9. Motor: UL Listed, ODP, Thermal overload protection, continuous duty.

B. Performance / Design Criteria: Manufacturer must have a minimum of 10 years' experience within industry. System shall be capable of filtering the entire tank volume with a required filtration run-time of ideally 24 hours but no more than 48 hours. Sufficient sediment as well as water-holding capacity should be ensured. System run-time requirements will vary with climate, tank-layout, fuel delivery, refueling intervals, etc. and shall be adjusted in accordance with the input from pressure and vacuum gauges as well as water sensor.

C. Operation System shall provide dry contacts for summary alarm and leak detection alarm to interface with building monitoring or building alarm system. An external shut down feature shall be provided to interrupt pump operation from the Building Management System (BMS).

2.6 DUCT MOUNTED LOAD BANK WITH AUTOMATIC LOAD LEVELING CONTROL

A. Provide a UL Listed, "In-Line" Duct Mounted Resistive Load Bank. The load bank shall be suitable for installation in the following ambient conditions:

1. Seismic Rating: Zone 4

2. Ambient Temperature: -20ºF to +120ºF

3. Altitude: 5,000 feet above sea level

B. The Load Bank will be sized at 30% maximum of the GenSet KW rating.

C. The load bank will be rated for a continuous duty cycle at 350KW at 480 Volts AC, 3-phase, 60 Hertz. The Load Step Resolution shall be approximately 20 percent of the total load bank capacity. Provide circuit breaker for the load bank.

D. The Engine fan shall deliver the required airflow volume (CFM) for cooling the resistor load elements.

E. The load bank enclosure is an open resistor frame of galvanized steel construction. The steel frame provides a 2 ½" mounting flange for direct mounting/coupling to the engine exhaust duct.

F. All power connections including main-input load bus and customer interface connections are made within the enclosed relay/connection compartment. Bottom access through a removable gland plate provides a "safe and sealed" ease of installation of all conduit entry cable. Load connections are made directly to the main input load bus bars. A standard NEMA 4-hole pattern shall be provided for customer load cables connections. All copper bus bars are plated for superior oxidation resistance. Relay/connection compartment is heated and thermostatically controlled to limit any harmful effects of condensation.

G. The load bank control circuits will be operated at 120 VAC AC, 1-phase. The control power will be derived from a control transformer. The Control Transformer will be primary and secondary fuse protected.

H. Resistor load element provide the necessary KW load rating for each load step. Resistors are fully supported across their entire length within the air stream by stainless steel support rods which are insulated with heavy-duty, high temperature ceramic insulators. The change in resistance is minimized by maintaining conservative resistor designs.

I. Branch circuit fuse protection provides short-circuit protection of all load steps. Fuses are fast-acting, current-limiting type with an interrupting rating of 200K A.I.C.

J. The load bank will include safety circuits which will disable the load bank if an over-temperature condition occurs. Load cannot be reapplied until the fault condition is corrected.

K. Load Bank Control Panel will be installed locally on the load bank. The control panel will include; Main Power On/Off switch, Master Load On/Off switch, and Individual Load Step switches KW On/Off). Illuminated indicators provide Power On, Blower On, Over-Temperature and Load Dump. An Emergency-Stop (E-STOP) push button is provided to disable control power voltage to all operator control circuits and load application circuits.

L. Automatic Load Leveling Control will add/subtract load bank load in response to dynamic power fluctuations of the connected building load. It utilizes the load bank as a supplemental load for maintaining a minimum load on the power source. A customer supplied "transfer of control" contact closure initiates the load bank and time delay load application circuit. A separately supplied current transformer provides the necessary feedback signal for sensing the building load.

M. Automatic Load Dump circuit provides user interface provisions to the generator controls, automatic transfer switch, to disconnect and disable all load steps from a normally closed (NC) set of auxiliary contacts. In the event of an actual power failure, all load bank load is removed from the source under test.

N. Remote Indication and Alarm contact closure form-c-type, normally open and normally closed, provides user interface to building management system for indication, detection and alarm of Over-Temperature and Load Dump.

2.7 CONTROL AND MONITORING

A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of generator set. When mode-selector switch is switched to the on position, generator set starts. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms.

B. Manual Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts generator set. The off position of same switch initiates generator-set shutdown. When generator set is running, specified system or equipment failures or derangements automatically shut down generator set and initiate alarms.

C. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the generator set. Mounting method shall isolate the control panel from generator-set vibration.

D. Readouts:

1. Engine oil pressure
2. Coolant temperature
3. Engine RPM
4. System DC Voltage
5. Engine running hours
6. Generator AC volts
7. Generator frequency
8. Generator AC amps

E. Solid state engine monitoring system with monitors in accordance with NFPA 70, NFPA 110 and local code requirements with lamps, audible alarm, lamp test switch, individual alarm contacts and a common alarm contact for:

1. Overcrank shutdown
2. Low coolant temperature warning
3. Pre-warning for high engine temperature
4. High engine temperature shutdown
5. Pre-warning for low lube oil pressure
6. Low lube oil pressure shutdown
7. Overspeed shutdown
8. Low fuel in main tank warning
9. Low coolant level warning
10. Generator (EPS) supplying load.
11. Generator control switch not in auto position warning
12. High battery voltage warning

13. Low cranking voltage warning
14. Low battery voltage warning
15. Battery charger failure
16. Generator output breaker(s) open warning
17. Emergency stop depressed
18. [Customer alarm]
19. [Customer alarm]
20. [Customer alarm]
21. Provide two dry auxiliary contacts one for common alarm and one for engine running.

F. Control Functions / Interfaces: Provide the following control functions:

1. Terminals located inside the control panel for REMOTE EMERGENCY STOP
2. ON / OFF / AUTO control switch

G. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.

H. Common Remote Audible Alarm: Comply with NFPA 110 requirements for Level 1 systems. Include necessary contacts and terminals in control and monitoring panel.

1. Overcrank shutdown.
2. Coolant low-temperature alarm.
3. Control switch not in auto position.
4. Battery-charger malfunction alarm.
5. Battery low-voltage alarm.

I. Remote Alarm Annunciator

1. Flush mounted remote annunciators shall be microprocessor based annunciator with network communication type, located as shown on the Drawings, and shall have audible and LED visual signal devices, powered by the electric set lead acid battery set, to provide a warning of derangement or alarm conditions in the electric set in compliance with the NFPA 70, NFPA 110 level 1, 20 lamp and the requirements of these Specifications. The enclosure shall be constructed of sturdy sheet steel, and shall have removable front panel and adapter ring for flush mounting. The face of the front panel shall contain LED's (visual signals), and audible alarm, an alarm silence push button, and a LED test push button. The internal wiring, terminal block, and battery voltage sensors shall be accessible by removing the front panel of the enclosure.
2. Remote annunciators shall indicate the following conditions:
    a. Overcrank shutdown
    b. Low coolant temperature warning
    c. Pre-warning for high engine temperature
    d. High engine temperature shutdown
    e. Pre-warning for low lube oil pressure

f. Low lube oil pressure shutdown

g. Overspeed shutdown

h. Low coolant level warning

i. Generator control switch not in auto position warning

j. Low cranking voltage warning

k. Low battery voltage warning

l. Generator output breaker(s) open warning

m. Generator power available

n. Low fuel in main tank warning

o. Fuel in outer tank

p. Emergency stop depressed

q. Load Bank Connected

r. Load Bank Over-Temperature

s. Load Bank Load Dump

t. Permanent generator Disconnected/Portable Generator (signal from manual transfer switch)

u. Spare/Customer alarm

v. Spare/Customer alarm

3. Visible indicator for:

a. Battery voltage okay

2.8 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Generator Circuit Breakers: shall be Standard Micrologic (LSI or where applicable LSIG) with solid-state trip unit and flux transfer shunt trip. Breakers shall have trip rating plugs with ratings as indicated on the drawings Rating plugs shall be interlocked so they are NOT interchangeable between frames and interlocked such that a breaker cannot be latched with the rating plug removed; 100 percent rated; adjust breaker frame to achieve selective coordination per NFPA 70 complying with NEMA AB 1 and UL 489.

1. Tripping Characteristic: Designed specifically for generator protection.

2. Trip Rating: Matched to generator rating.

3. Shunt Trip: Connected to trip breaker when generator set is shut down by other protective devices.

4. Mounting: Adjacent to or integrated with control and monitoring panel.

B. Ground-Fault Indication: Comply with NFPA 70, "Emergency System" signals for ground-fault. Integrate ground-fault alarm indication with other generator-set alarm indications.

C. The generator circuit breakers shall be of the same manufacturer as the ones provided on the supply side for switchboards and panelboards.

D. All emergency system overcurrent devices be selectively coordinated with the overcurrent devices installed on their supply side per Section 700.27 of the National Electrical Code.

E. Each generator circuit breaker shall be installed in a separate enclosure to physically separate the circuit breakers feeding the different emergency branches i.e. Emergency Life Safety, Legally Required Standby, Optional Standby, Fire Pump, etc.

2.9 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1.

B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

C. Electrical Insulation: Class H or Class F.

D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required.

E. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, over-speed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.

F. Enclosure: Drip-proof.

G. Delete first paragraph below if instrument transformers are housed in control and power panel.

H. Instrument Transformers: Mounted within generator enclosure.

I. Voltage Regulator: Solid-state type, separate from exciter, providing performance as specified.

1. Adjusting rheostat on control and monitoring panel shall provide plus or minus 5 percent adjustment of output-voltage operating band.

J. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

K. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

L. Sub-transient Reactance: 12 percent, maximum.

2.10 SOUND ATTENUATED WEATHER PROTECTIVE OUTDOOR GENERATOR-SET ENCLOSURE

A. A weatherproof, sound attenuated, enclosure shall be provided to house the engine/generator and accessories. The enclosure is to be in compliance with the National Electrical Code (NEC), and the National Fire Protection Association (NFPA) for clearance around electrical equipment as specified. The enclosure shall conform to the following design criteria:

1. Material: Aluminum min. thickness 16 gauge.
2. Rigidity wind test equal to 115 MPH
3. Roof load equal to 50 lbs. per sq. ft.
4. Floor load equal to 200 lbs. per sq. ft.
5. Rain test equal to 4" per hour
6. Certified to meet the BOCA basic bldg. and mech. Codes
7. The sound attenuation shall be Level I not to exceed 76dB at 23 ft.
8. The generator length and width dimension shall not exceed 290” L x 120” W due to location restrictions.

B. Provide stairs complete with platforms, railings, and handrails to provide full access to each service access door. They shall be aluminum, hot-dipped galvanized after fabrication. They shall comply with the applicable building codes, OSHA standards, State Occupational Safety and Health Plan requirements, and other applicable regulations. Enclosures without platforms, railings, and handrails shall not be acceptable. Note: the generator sits on a concrete pad, coordinate and verify dimensions prior to construction of the platform.

C. Test data on similar construction by manufacturer, reviewed by a P.E. licensed in the Commonwealth of Massachusetts, shall be available upon request.

D. Enclosure will consist of a roof, fuel tank and rupture basin base, two (2) side walls, and two (2) end walls, of stressed skin, semi-monocoque construction.

E. The system shall include a cooling and combustion air inlet silencer section, an equipment enclosure section, and a cooling air discharge silencer section. enclosure shall be designed as follows:

1. Roof and walls shall each be of one-piece semi-monocoque construction. All framing members shall be 6063-T6 aluminum. Skin material shall be min. thickness 16 gauge pre-painted aluminum (roof shall be mill-finish). A minimum of six colors shall be available for enclosure exterior. Skin panels shall be hard-riveted to framing members on 3" centers maximum. Pop rivets and bolts are not acceptable fasteners to attach exterior skin to framing. Roof assembly shall be cambered to aid in rain runoff.

2. Insulation in walls and roof shall be semi-rigid, thermo-acoustic, thickness as required to meet the noise criteria specified. Lining shall be perforated, mill- finish aluminum. Self-adhesive foam and loose or bat-type insulating materials will not be accepted.

F. An integral fuel tank underframe with floor and rupture basin shall be supplied, consisting of the following: a rupture basin utilizing minimum 7 ga. steel channel perimeter walls and bottom; a U.L. listed (per U.L. 142) above-ground rectangular tank of minimum 12 ga. steel construction; and a floor system consisting of fabricated or structural steel cross members on centers averaging 16 inches. The cross members will be overlaid with OSB board topped with 14 ga. steel diamond plate. This wood/steel combination must be used for acoustic isolation of the generator set from base. The tank shall have venting and emergency venting per U.L. 142, lockable fill, low level and high level alarm contacts, and a D.C. electric analog level gauge. The cross members shall incorporate 3/8" thick steel tapping plates for genset mounting. The rupture basin shall have a float contact to indicate tank rupture, and the entire system shall be leak tested prior to installation.

G. Four-point lifting provisions shall be provided at or near the enclosure base, with capacity suitable for rigging the entire assembly. Quality assurance procedures of the manufacturer shall include regular testing of the lift devices.

H. Two (2) single personnel access doors shall be provided. Door shall consist of an extruded aluminum frame with skin material matching enclosure. Door shall be fully gasketed to form a weather tight perimeter seal. Hinges shall be forged aluminum with stainless steel pins, handle shall be stainless steel and padlockable, and lock mechanism shall be three-point, with panic hardware to allow opening from inside even when padlocked. Include stairs and entry platform at each door.

I. Air handling shall be as follows: Air will enter the enclosure through removable hood(s) or an integral, baffled plenum. Motor operated damper(s) will be provided, wired to open upon engine startup. Radiator discharge will be through a gravity operated damper and into a hood or vertical plenum, as dictated by airflow. The system shall not exceed 0.5" w.g. total external static pressure to ensure adequate airflow for cooling and combustion.

J. A bolt-in-place removable wall panel shall be provided for maintenance and/or equipment installation.

K. Enclosure manufacturer shall provide all necessary hardware to internally mount the specified exhaust silencer(s) and maintain the weatherproof integrity of the system. Silencer and exhaust flex shall be insulated. Include a 10' stainless steel concentric exhaust extension when required by local code.

L. The enclosure shall include A.C. and D.C. lighting, duplex receptacles, and an A.C. distribution panel. D.C. lights to have timer type switch. All devices in the enclosure, including specified generator set accessories, shall be prewired in E.M.T. by enclosure manufacturer. In addition, the manufacturer shall perform the system integration of all components in the enclosure, mechanical and electrical. The enclosure shall include:

1. Mechanical ventilation and an electric unit heater thermostatically controlled suitable to maintain space temperature of maximum 95°F, minimum 50°F in Massachusetts.

M. Interior Lights with Switch: Factory-wired, vaporproof-type fixtures within housing; arranged to illuminate controls and accessible interior. Arrange for external electrical connection.

1. AC lighting system and connection point for operation when remote source is available.

2. DC lighting system for operation when remote source and generator are both unavailable.

N. Convenience Outlets: Factory wired**,** GFCI. Arrange for external electrical connection.

O. A 100 AMP main breaker 208Y/120V 3-phase 4-wire 12-pole panelboard with all necessary circuit breakers for serving engine jacket water heater, battery charger, electric unit heater, etc.

2.11 STACK HEIGHT AND EMISSION DISPERSION

A. All engines or turbines shall utilize an exhaust stack that discharges so as to not cause a condition of air pollution (310 CMR 7.01(1)). Exhaust stacks shall be configured to discharge the combustion gases vertically and shall not be equipped with any part or device that restricts the vertical exhaust flow of the emitted combustion gases, including but not limited to rain protection devices "shanty caps" and "egg beaters". Any emission impacts of exhaust stacks upon sensitive receptors including, but not limited to, people, windows and door, that open, and building fresh air intakes shall be minimized by employing good air pollution control engineering practices. Such practices include without limitation:

1. Avoiding locations that may be subject to downwash of the exhaust;

2. Installing stack(s) of sufficient height in locations that will prevent and minimize flue gas impacts upon sensitive receptors.

B. Engines or turbines with a rated power output equal to or greater than 300 kW, but less than 1 MW, shall have a minimum stack height of ten feet above the facility rooftop or the emergency engine or turbine enclosure, whichever is lower.

C. Engines with a rated power output equal to or greater than one MW shall be equipped with a stack with a minimum stack height of 1.5 times the height of the building on which the stack is located. If the stack is lower than 1.5 times the building height or lower than the height of a structure that is within 5L of the stack (5L being five times the lesser of the height or maximum projected width of the structure), an EPA Guideline air quality model shall be run to document that the operation of the applicable emergency engine or turbine will not cause an exceedance of any National Ambient Air Quality Standard.

2.12 VIBRATION ISOLATION DEVICES

A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.

B. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.

2. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.

3. Minimum Additional Travel: 50 percent of required deflection at rated load.

4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.

5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.13 FINISHES

A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

2.14 EMERGENCY STOP BUTTON

A. Furnish and install an emergency stop button and wiring on the exterior of the generator enclosure and next to each transfer switch.

B. The emergency stop button shall be:

1. Pilla Electrical Products, Inc., Model ST120SN3RSL-GLS or approved equal. Surface mount, NEMA 3R with 2 replacement glasses and painted steel enclosure.

2.15 INTEGRATION TO BUILDING MANAGEMENT SYSTEM (BMS):

A. Provide Modbus RS-485 communications wiring from the generator to:

1. BMS system.

2. Generator Annunciator.

B. The BMS system shall monitor the following points:

1. Overcrank shutdown

2. Low coolant temperature warning

3. Pre-warning for high engine temperature

4. High engine temperature shutdown

5. Pre-warning for low lube oil pressure

6. Low lube oil pressure shutdown

7. Overspeed shutdown

8. Low fuel in main tank warning
9. Low coolant level warning
10. Generator (EPS) supplying load.
11. Generator control switch not in auto position warning
12. High battery voltage warning
13. Low cranking voltage warning
14. Low battery voltage warning
15. Battery charger failure
16. Generator output breaker(s) open warning
17. Emergency stop depressed
18. Load Bank Connected
19. Load Bank Over-Temperature
20. Load Bank Load Dump
21. Permanent generator Disconnected/Portable Generator (signal from manual transfer switch)
22. Spare/Customer alarm
23. Spare/Customer alarm

C. The electrical contractor shall provide wiring from the BMS system to the generator for the load bank “transfer of control” contact closure to initiate the load bank and time delay load application circuit.

D. The electrical contractor shall provide wiring from the generator to the BMS for indication, detection and alarm of Load Bank Over-Temperature and Load Dump.

E. Coordinate exact requirements with the BMS vendor.

2.16 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

1. Tests: Comply with NFPA 110 and with IEEE 115.
2. Report factory test results within 10 days of completion of test.

2.17 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Perform tests recommended by manufacturer and each electrical test and visual and mechanical inspection for "AC Generators and for Emergency Systems" specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.

2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.

3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.

   a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.

   b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.

   c. Verify acceptance of charge for each element of the battery after discharge.

   d. Verify that measurements are within manufacturer's specifications.

4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.

5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine-generator system before and during system operation. Check for air, exhaust, and fluid leaks.

6. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg (120 kPa). Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.

7. Verify local requirements and delete first subparagraph below for most projects. Few jurisdictions require this test for emergency or standby generator sets.

8. Exhaust Emissions Test: Comply with applicable government test criteria.

9. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.

10. Harmonic-Content Tests: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.

11. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at four locations on the property line, and compare measured levels with required values.

C. Coordinate tests with tests for transfer switches and run them concurrently.

D. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

E. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

F. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

G. Remove and replace malfunctioning units and retest as specified above.

H. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

I. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

2.18 LOAD BANK TEST

A. Provide all equipment, labor, materials, and supervision necessary to test the stand-by diesel engine driven electric generator set specified. Tests shall be performed as installed on-site.

B. Acceptance testing of the installed generator set shall be conducted by a factory trained representative of the generator set manufacturer. An authorized representative of the Owner will also witness the acceptance tests.

C. The test results shall be submitted to and approved by the Engineer before the generator set is accepted. The Contractor shall furnish all testing equipment, materials, fuel, etc., needed to demonstrate the set is in compliance with the specification. Any deficiencies brought to the attention of the Contractor shall be corrected and if warranted or requested by the Owner, the test shall be re-performed prior to acceptance. Final Operations & Maintenance (O&M) manuals shall be submitted before the acceptance tests commence.

D. The acceptance tests shall be performed during a field test during which the manufacturer’s representative shall demonstrate that the system performs in complete compliance with the specifications. As a minimum, a load bank test performed in accordance with NFPA 110 shall be conducted. The load test shall use dry type load banks specifically utilized for this purpose. The load bank will be capable of definite and precise incremental loading and shall not be dependent on the generator control instrumentation to read voltage and amperage of each phase. The test instrumentation will serve as a check of the generator set meters. Salt water brine tank load banks are not acceptable for this purpose and are disallowed and will not be utilized for this test.

E. Load bank testing shall be performed as follows or per the manufacturer’s recommendations, 1-hour at 33%, then 1-hour at 66%, then 2-hours at 100%, rated load of the generator and witnessed by the Owner’s representative.

F. The Electrical Trade Contractor shall provide a full tank of diesel fuel for the completion of all testing.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.

B. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

C. Install packaged engine generator with restrained spring isolators having a minimum deflection of 1 inch (25 mm) on 4-inch- (100-mm-) high concrete base. Secure sets to anchor bolts installed in concrete bases. Concrete base construction is specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

D. Install Schedule 40, black steel piping with welded joints and connect to engine muffler. Install thimble at wall. Piping shall be same diameter as muffler outlet. Flexible connectors and steel piping materials and installation requirements are specified in Division 22.

1. Install condensate drain piping to muffler drain outlet full size of drain connection with a shutoff valve, stainless-steel flexible connector, and Schedule 40, black steel pipe with welded joints. Flexible connectors and piping materials and installation requirements are specified in Division 22.

E. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

F. Piping installation requirements are specified in Division 22 Sections. Drawings indicate general arrangement of piping and specialties.

G. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine generator to allow service and maintenance.

H. Connect engine exhaust pipe to engine with flexible connector.

I. Connect fuel piping to engines with a gate valve and union and flexible connector.

J. Ground equipment according to Division 26.

K. Connect wiring according to Division 26.

L. Identify system components according to Division 22 and Division 26.

3.2 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine-generator set using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

1. Tests: Comply with NFPA 110 and with IEEE 115.
2. Report factory test results within 10 days of completion of test.

3.3 FIELD QUALITY CONTROL

A. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

B. Tests and Inspections:

1. Perform tests recommended by manufacturer and each electrical test and visual and mechanical inspection for "AC Generators and for Emergency Systems" specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.
3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.

a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
c. Verify acceptance of charge for each element of the battery after discharge.
d. Verify that measurements are within manufacturer's specifications.

4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine-generator system before and during system operation. Check for air, exhaust, and fluid leaks.
6. Exhaust-System Back-Pressure Test: Use a manometer with a scale exceeding 40-inch wg (120 kPa). Connect to exhaust line close to engine exhaust manifold. Verify that back pressure at full-rated load is within manufacturer's written allowable limits for the engine.
7. Verify local requirements and delete first subparagraph below for most projects. Few jurisdictions require this test for emergency or standby generator sets.
8. Exhaust Emissions Test: Comply with applicable government test criteria.
9. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases and verify that performance is as specified.
10. Harmonic-Content Tests: Measure harmonic content of output voltage under 25 percent and at 100 percent of rated linear load. Verify that harmonic content is within specified limits.
11. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at four locations on the property line, and compare measured levels with required values.

C. Coordinate tests with tests for transfer switches and run them concurrently.

D. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

E. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.

F. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

G. Remove and replace malfunctioning units and retest as specified above.

H. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

I. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

3.4 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup checks according to the approved manufacturer's written instructions.

3.5 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct four 4-hour training sessions. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

End of Section

Section 26 33 53

STATIC UNINTERRUPTIBLE POWER SUPPLY

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. This specification describes a three-phase continuous duty, on-line, double conversion, solid-state uninterruptible power system, hereafter referred to as the UPS. The UPS shall operate in conjunction with the existing building electrical system to provide power conditioning, back up and distribution for critical electrical loads. The UPS shall consist of, as required by the project, the UPS module, batteries, or other DC storage systems, and accessory cabinet(s) for transformers, maintenance bypass, and distribution applications, and other features as described in this specification.

1.4 UPS SYSTEM DESCRIPTION

A. UPS System Components: The UPS system shall consist of the following main components:

1. UPS module containing Rectifier(s), Inverter(s), Battery Charger(s), Static Bypass, and associated Control and Monitor Panel.
2. Battery string(s) in Line-and-Match Battery Cabinets.
3. Line-and-Match and/or sidecar-type accessory cabinets for transformer, maintenance bypass, parallel tie and distribution applications. Specific accessory availability depends on UPS model.

B. UPS Module Modes of Operation: The UPS Module shall operate as an on-line, fully automatic system in the following modes:

1. Normal: Utilizing commercial AC power, the critical load shall be continuously supplied by the Inverter. The Inverter shall power the load while regulating both voltage and frequency. The Rectifier shall derive power from the commercial AC source and shall supply DC power to the Inverter. Simultaneously, the Battery Charger shall charge the battery.

2. Battery: Upon failure of the commercial AC power, the critical load shall continue to be supplied by the Inverter, which shall obtain power from the batteries without any operator intervention. There shall be no interruption to the critical load upon failure or restoration of the commercial AC source. The 93PM UPS shall be capable of operating with 432V or 480VDC battery systems.
3. Recharge: Upon restoration of the AC source, the Charger shall recharge the batteries and simultaneously the Rectifier shall provide power to the Inverter. This shall be an automatic function and shall cause no interruption to the critical load.
4. Bypass: If the UPS module must be taken out of the Normal mode for overload, load fault, or internal failures, the static bypass switch shall automatically transfer the critical load to the commercial AC power. Return from Bypass mode to Normal mode of operation shall be automatic. No-break transfer to and from Bypass mode shall be capable of being initiated manually from the front panel.
5. Energy Saver: The UPS shall continuously monitor the voltage and frequency of the bypass source. When the source parameters are within acceptable limits, the UPS will utilize a minimal/optimal combination of its internal subsystems to ensure acceptable power is always delivered to the critical load, at a system efficiency of up to 99.1%. The Energy Saver System shall be enabled by the user, and shall be adjustable. It shall incorporate a “High Alert Mode” to automatically (without user intervention) provide maximum power conditioning any time bypass source variation levels exceed preset, adjustable limits. When Energy Saver System is utilized, the UPS shall attenuate ANSI C62.41-type line transients to within IEC and ITIC limits. The Energy Saver System shall be able to distinguish between upstream (utility) faults and downstream (load) faults, and react appropriately to protect and support the critical load, without interruption.

1.5 REFERENCES

A. UL 1778 (Underwriters Laboratories) – Standard for Uninterruptible Power Supply Equipment. Product safety requirements for the United States, 4th Edition.

B. CSA C22.2 No 107.1(Canadian Standards Association) – Commercial and Industrial Power Supplies. Product safety requirements for Canada.

C. NEMA PE-1 – (National Electrical Manufacturers Association) – Uninterruptible Power Systems standard.

D. IEC 62040-2 C3

E. IEC 62040-3 (International Electrotechnical Commission) – Uninterruptible power systems (UPS) – Part 3: Method of specifying the performance and test requirements.

F. IEEE 587 (ANSI C62.41) Category A & B (International Electrical and Electronics Engineers) – Recommended practices on surge voltages in low voltage power circuits.

G. CISPR 22 and 24, FCC Rules and Regulations 47, Part 15, Class A (Federal Communications Commission) – Radio Frequency Devices.

1.6 SUBMITTALS

A. The UPS shall be supplied with sufficient documentation, including the following manuals:

1. Installation and Operation Manual: One copy of the installation and operation manual shall be furnished. It shall possess sufficient detail and clarity to enable the owner’s

technicians or representatives to install and operate the UPS equipment and accessories. The manual shall include the following major items:

a. UPS description
b. UPS site planning and unpacking
c. UPS installation
d. Optional accessory installation
e. UPS theory of operation
f. Operating procedures
g. System events
h. UPS maintenance
i. Performance and technical specifications
j. Wiring requirements and recommendations
k. Physical features and requirements
l. Cabinet dimensions

1.7 QUALIFICATIONS

A. The UPS manufacturer shall have a minimum of fifty years' experience in the design, manufacture and testing of solid-state UPS systems. A list of installed UPS systems of the same type as the manufacturer proposes to furnish for this application shall be supplied upon request.

B. The UPS manufacturer shall have ISO 9001 certification for engineering/R&D, manufacturing facilities and service organization.

C. The UPS manufacturer shall maintain a staffed 7x24x365 call center for technical and emergency support.

D. Field Engineering Support: The UPS manufacturer shall directly employ a nationwide field service department staffed by factory-trained field service engineers dedicated to startup, maintenance, and repair of UPS equipment. The organization shall consist of local offices managed from a central location. Field engineers shall be deployed in key population areas to provide on-site emergency response within 24 hours. A map of the United States showing the location of all field service offices shall be submitted with the proposal. Third-party service or maintenance will not be accepted.

E. Spare Parts Support: Parts supplies shall be located in the field to provide 80% of all emergency needs. Parts are stocked in regional logistics centers, ensuring a 95% First Time Fix rate and maximizing system availability.

F. Product Enhancement Program: The UPS manufacturer shall make available feature upgrade service offerings to all users as they are developed. These upgrades shall be available as optional field-installable kits.

G. Maintenance Contracts: A complete range of preventative and corrective maintenance contracts shall be provided and offered with the proposal. Under these contracts, the manufacturer shall maintain the user's equipment to the latest factory revisions.

1.8 ENVIRONMENTAL REQUIREMENTS

A. The UPS shall withstand any combination of the following external environmental conditions without operational degradation.

1. Operating Temperature: +5 degrees C to +40 degrees C (41 degrees F to 104 degrees F) without de-rating (excluding batteries).
2. Storage Temperature: -25 degrees C to +55 degrees C (-13 degrees F to 131 degrees F). Prolonged storage above + 40 degrees C (104 degrees F) will cause rapid self-discharge and permanent damage to the battery.
3. Relative Humidity (operating and storage): 5-95% non-condensing.
4. There shall be at least a 1.8ºF (1.0ºC) difference between the dry bulb temperature and the wet bulb temperature, at all times, to maintain a non-condensing environment.
5. The maximum rate of temperature change shall be limited to 3ºF over 5 minutes (36ºF/hour), based on the ASHRAE Standard 90.1-2013
6. Elevation:
   a. Operational: 5000 ft. (1500 m) maximum without de-rating. Above this rating, altitude de-rating as per IEC 62040-3
   b. Transportation: Capable of air transport, up to 15,000m.

1.9 SAFETY

A. The UPS shall be certified by Underwriters Laboratories in accordance with UL 1778, 4th Edition.

B. The UPS shall be certified by the Canadian Standards Association in accordance with CSA C22.2 NO.107.1-M91.

C. Cabinet shall be NEMA 1 and IP20 rated.

1.10 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers

1. Eaton.
2. Schneider Electric.
3. MGM.
4. Or approved equal.

B. Basis of Design: the system and materials specified are based upon products by Eaton – 93PM 100kW N+1 UPS with maintenance bypass, batteries, and power distribution unit (PDU); and represent the performance standard upon which any equivalent solution shall be based.

2.2 UPS MODULE STANDARD FEATURES

A. The UPS module shall consist of the following standard components, housed in a 100kW frame:

1. Quantity (3) identical 50kW UPM Universal Power Modules, each containing:
   a. Rectifier/Charger: The rectifier/charger shall convert incoming AC power to regulated DC output for supplying the inverter and for charging the battery. The rectifier/charger shall be a high-frequency PWM design, using Insulated Gate Bi-polar Transistors (IGBTs). The modular design of the UPS shall permit safe and fast removal and replacement of the rectifier/charger module. Mean time to repair (MTTR) for the module shall be no more than 30 minutes in order to return UPS to normal mode. The rectifier/charger module shall also provide the following:
   b. The rectifier shall be capable of drawing power from the utility with a power factor of 0.99 under nominal conditions.
   c. The rectifier shall feature protection circuitry that prevents the IGBTs from sourcing current in excess of their published ratings.
   d. Inverter: The inverter shall feature an IGBT pulse-width-modulation (PWM) design with high-speed switching. The inverter shall also have the following features:
   e. The inverter shall be capable of providing the specified quality output power while operating from any DC source voltage (rectifier or battery) within the specified DC operating range.
   f. The modular design of the UPS shall permit safe and fast removal and replacement of the power module, while in maintenance bypass. Mean time to repair (MTTR) for the module shall be no more than 30 minutes in order to return UPS to normal mode.
   g. The inverter shall feature protection circuitry that prevents the IGBTs from sourcing current in excess of their published ratings.

B. Static Bypass: The bypass shall serve as an alternative source of power for the critical load when an abnormal condition prevents operation in normal mode. The bypass for 50-200kW frames shall consist of a fully rated, continuous duty, naturally commutated static switch for high-speed transfers. The bypass shall feature the following transfer and operational characteristics.

1. Transfers to bypass (for stand alone, and parallel capacity systems) shall be automatically initiated for the following conditions:
   a. Output overload period expired.
   b. Critical bus voltage out of limits.
   c. Internal over temperature period expired.
   d. Total battery discharge.
   e. UPS failure.

2. Parallel Redundant UPS systems shall transfer to bypass on conditions (a), (b), and (d) above. Conditions (c) and (e) will result in the affected UPS isolating itself from the parallel bus, allowing the remaining UPS(s) to support the critical load.
3. Uninterrupted automatic re-transfer shall take place whenever the inverter(s) is capable of assuming the critical load.
4. Uninterrupted automatic re-transfers shall be inhibited for the following conditions:
   a. When transfer to bypass is activated manually or remotely.
   b. In the event of multiple transfers/re-transfer operations the control circuitry shall limit “cycling” to three (3) operations in any ten-minute period. The third transfer shall lock the critical load on the bypass source, for 60 minutes.
   c. UPS failure.

5. Uninterrupted manual transfers shall be initiated from the control panel. Uninterrupted manual transfers to bypass and from bypass shall be possible with the inverter logic. During manual transfers to bypass mode, the inverter must verify proper bypass operations before transferring the critical load to the bypass.

6. All transfers to bypass shall be inhibited for the following conditions:
   a. Bypass voltage out of limits (+10%, to -10% of nominal)
   b. Bypass frequency out of limits (+/- 4 Hz, adjustable, factory set)
   c. Bypass out of synchronization
   d. Bypass phase rotation / installation error

7. Static transfer time: No break, complete in less than 4ms.
8. The bypass shall be manually energized using the control panel or remotely through a building alarm input.

C. Monitoring and control components: The following components shall provide monitor and control capability:

1. Control panel: color LCD, touch sensitive, with LED status indicators.
2. Alarm and metering display.
3. Building alarm monitoring.
4. Communication ports: RS-232 and USB.

D. Battery management system: The UPS shall contain a battery management system which has the following features:

1. The battery management system shall provide battery time remaining while operating in normal mode and battery mode. Battery time available information shall be displayed real-time, even under changing load conditions. Upon commissioning, battery runtime information shall be available.
2. The battery management system shall automatically test the battery system to ensure that the battery is capable of providing greater that 80% of its rated capacity. Testing the batteries shall not jeopardize the operation of the critical load. Upon detection of the battery string(s) not capable of providing 80%, the UPS system will alarm that the battery needs attention/replacement. The battery test shall be able to detect the following:
   a. Open battery string
   b. Shorted battery string (current limit)
   c. Battery capacity (runtime) less than 80% of “new” battery capacity

E. Wiring Terminals: The UPS 100kW frame modules shall contain mechanical compression terminals (adequately sized to accommodate 75 degree C wiring).

1. Rectifier/charger input connections (3-wire plus ground, or 4-wire plus ground for 4-wire models)
2. Bypass input connections, (for dual source configurations): 3-wire plus ground for 3-wire plus ground output configuration (480Vac), or 4-wire plus ground for 4-wire plus ground output configuration (480/277Vac)
3. DC link connections for battery cabinets (positive and negative plus ground).
4. AC output connections (3 wires plus ground, or 4-wire plus ground for 4-wire models), 4 wire plus ground if distribution accessory cabinet with transformer is utilized.

2.3 UPS MODULE OPTIONS AND ACCESSORIES

A. Integrated Maintenance Bypass, Distribution, Parallel Tie and Accessory Cabinet(s): Integrated Line-and-Match cabinet(s) shall be provided that include(s):

1. Rectifier/Charger: The rectifier/charger shall convert incoming AC power to regulated DC output for supplying the inverter and for charging the battery. The rectifier/charger shall

be a high-frequency PWM design, using Insulated Gate Bi-polar Transistors (IGBTs). The modular design of the UPS shall permit safe and fast removal and replacement of the rectifier/charger module. Mean time to repair (MTTR) for the module shall be no more than 30 minutes in order to return UPS to normal mode. The rectifier/charger module shall also provide the following:

2. The rectifier shall be capable of drawing power from the utility with a power factor of 0.99 under nominal conditions.
3. The rectifier shall feature protection circuitry that prevents the IGBTs from sourcing current in excess of their published ratings.
4. Inverter: The inverter shall feature an IGBT pulse-width-modulation (PWM) design with high speed switching. The inverter shall also have the following features:
5. The inverter shall be capable of providing the specified quality output power while operating from any DC source voltage (rectifier or battery) within the specified DC operating range.
6. The modular design of the UPS shall permit safe and fast removal and replacement of the power module, while in maintenance bypass. Mean time to repair (MTTR) for the module shall be no more than 30 minutes in order to return UPS to normal mode.
7. The inverter shall feature protection circuitry that prevents the IGBTs from sourcing current in excess of their published ratings.

B. Static Bypass: The bypass shall serve as an alternative source of power for the critical load when an abnormal condition prevents operation in normal mode. The bypass for 50-200kW frames shall consist of a fully rated, continuous duty, naturally commutated static switch for high-speed transfers. The bypass shall feature the following transfer and operational characteristics.

1. Transfers to bypass (for stand alone, and parallel capacity systems) shall be automatically initiated for the following conditions:
   a. Output overload period expired.
   b. Critical bus voltage out of limits.
   c. Internal over temperature period expired.
   d. Total battery discharge.
   e. UPS failure.

2. Parallel Redundant UPS systems shall transfer to bypass on conditions (a), (b), and (d) above. Conditions (c) and (e) will result in the affected UPS isolating itself from the parallel bus, allowing the remaining UPS(s) to support the critical load.
3. Uninterrupted automatic re-transfer shall take place whenever the inverter(s) is capable of assuming the critical load.
4. Uninterrupted automatic re-transfers shall be inhibited for the following conditions:
   a. When transfer to bypass is activated manually or remotely.
   b. In the event of multiple transfers/re-transfer operations the control circuitry shall limit “cycling” to three (3) operations in any ten-minute period. The third transfer shall lock the critical load on the bypass source, for 60 minutes.
   c. UPS failure.

5. Uninterrupted manual transfers shall be initiated from the control panel. Uninterrupted manual transfers to bypass and from bypass shall be possible with the inverter logic. During manual transfers to bypass mode, the inverter must verify proper bypass operations before transferring the critical load to the bypass.
6. All transfers to bypass shall be inhibited for the following conditions:
   a. Bypass voltage out of limits (+10%, to -10% of nominal)
   b. Bypass frequency out of limits (+/- 4 Hz, adjustable, factory set)
   c. Bypass out of synchronization

d. Bypass phase rotation / installation error

7. Static transfer time: No break, complete in less than 4ms.
8. The bypass shall be manually energized using the control panel or remotely through a building alarm input.

C. Monitoring and control components: The following components shall provide monitor and control capability:

1. Control panel: color LCD, touch sensitive, with LED status indicators.
2. Alarm and metering display.
3. Building alarm monitoring.
4. Communication ports: RS-232 and USB.

D. Battery management system: The UPS shall contain a battery management system which has the following features:

1. The battery management system shall provide battery time remaining while operating in normal mode and battery mode. Battery time available information shall be displayed real-time, even under changing load conditions. Upon commissioning, battery runtime information shall be available.
2. The battery management system shall automatically test the battery system to ensure that the battery is capable of providing greater that 80% of its rated capacity. Testing the batteries shall not jeopardize the operation of the critical load. Upon detection of the battery string(s) not capable of providing 80%, the UPS system will alarm that the battery needs attention/replacement. The battery test shall be able to detect the following:
   a. Open battery string
   b. Shorted battery string (current limit)
   c. Battery capacity (runtime) less than 80% of “new” battery capacity

E. Wiring Terminals: The UPS 100kW frame modules shall contain mechanical compression terminals (adequately sized to accommodate 75 degree C wiring).

1. Rectifier/charger input connections (3-wire plus ground, or 4-wire plus ground for 4-wire models)
2. Bypass input connections, (for dual source configurations): 3-wire plus ground for 3-wire plus ground output configuration (480Vac), or 4-wire plus ground for 4-wire plus ground output configuration (480/277Vac)
3. DC link connections for battery cabinets (positive and negative plus ground).
4. AC output connections (3 wires plus ground, or 4-wire plus ground for 4-wire models), 4 wire plus ground if distribution accessory cabinet with transformer is utilized.

2.4 UPS MODULE ACCESSORIES

A. Integrated Maintenance Bypass, Distribution, Parallel Tie and Accessory Cabinet(s): Integrated Line-and-Match cabinet(s) shall be provided that include(s):

1. All hardware and interconnecting cable for connection to UPS module. Exception is the IAC-D distribution cabinet.
2. IAC-B (Bypass) Sidecar: Three breaker manual maintenance bypass switch in a sidecar configuration, to isolate UPS module from commercial AC input and critical load. The sidecar may be mounted on either side of the UPS module. Switch shall provide complete isolation of UPS for servicing. Switch shall be make-before-break, interlocked

between UPS and bypass to prohibit improper operation. Breakers to be rated at 65kAIC.

3. IAC-D (Distribution) cabinet (20-200kW models): This may be positioned on either side of the UPS module, and shall include a K-13 rated output isolation and step down transformer. The transformer shall meet TP-1 specifications.
   a. The 100kW IAC-D shall house two (2), 42 pole distribution panels with main disconnects for a total of 84 poles of distribution. Branch breakers are to be provided and installed by the Electrical Contractor to match the panel schedules on the drawings.

B. Network Adapter and UPS Power Monitoring Software: PX Gateway card adapter shall provide a communications interface between the UPS module and the following network management systems.

1. SNMP v.1, v.3
2. Modbus TCP
3. BACnet/WS or /IP
4. IPv6

C. Relay Card: Serial dry contact card providing 4 isolated dry output contacts, 1 isolated input. The relays are programmable.

D. External Battery Cabinet: The battery cabinet shall feature valve regulated, high-rate discharge, lead-acid batteries which provide energy to the support the critical load during a momentary loss of input power to the rectifier. The batteries shall be flame retardant in accordance with UL 94V2 requirements. The battery cabinet shall have the following features:

1. The battery cabinet shall be capable of providing 11 minutes of runtime at 100kW full load.
2. The battery cabinet shall be the same depth and height as the UPS module.
3. The battery cabinet shall feature a mechanical enclosure of like appearance to the UPS module and shall feature casters for easy installation. Each battery cabinet shall require front access only for installation, service, and maintenance. The battery cabinet shall provide bottom cable entry standard and top entry capability via sidecar.
4. Power wiring internal to each battery cabinet shall be factory provided. Each battery cabinet shall feature up to 10 battery trays which can be individually disconnected from the battery cabinet power wiring with quick disconnect devices. Each battery tray shall be firmly secured to the battery cabinet frame with fasteners. Each battery tray shall be removable from the front of the battery cabinet.
5. Each battery cabinet shall feature a DC rated circuit breaker. The circuit breaker within the battery cabinet shall only provide protection to the battery string(s) within that battery cabinet. For battery configurations involving multiple battery cabinets, the batteries in one battery cabinet may be isolated from the DC link via its circuit breaker without disconnecting other battery cabinets from the DC link and the UPS module.
6. The circuit breaker in each battery cabinet shall feature an A/B auxiliary switch. The UPS module shall be capable of monitoring and alarming an open battery cabinet circuit breaker condition.
7. The circuit breaker in each battery cabinet shall feature a 48VDC shunt trip device. The shunt trip shall operate to trip the battery breaker(s) for an emergency power off command or battery disable command.
8. Power and Control wiring between the co-located battery cabinet and the UPS shall be factory provided.
9. The batteries shall be optionally configured with a ¼” spade type connector for attaching sense leads to each jar to facilitate the future addition of a battery monitoring system.

10. Expected battery life: 200 complete full load discharge cycles when operated and maintained within specifications.

2.5 UNINTERRUPTIBLE POWER SUPPLY RATINGS AND OPERATING CHARACTERISTICS

A. UPS Continuous Ratings. The UPS shall be rated: 100kW N+1 (internally redundant)

B. Acceptable UPS input sources:

1. 3-wire model UPS shall support 3-wire grounded Wye sources. A neutral conductor is not used from the source, and is not supplied to the load.
2. Single source, single or dual feed: 3-wire grounded neutral wye .
3. Dual source, dual feed: 3-wire grounded neutral wye.

C. 4-wire model UPS shall support 4-wire grounded Wye sources. A neutral conductor is used from the source and is supplied to the load. Rectifier/charger input:

1. Nominal three phase input voltage: 480 Vac or 480/277Vac for 4-wire models 3-wire plus ground for 3-wire plus ground output configuration or 4-wire plus ground for 4-wire plus ground output configuration
2. Operating input voltage range: +10%, -15% of average nominal input voltage without battery discharge. Note the UPS shall “power share” with the battery to -30% of nominal voltage, at full rated load.
3. Operating input frequency range shall be 40 to 72Hz.
4. Input power factor 0.99 lagging at rated load.
5. Normal input current limit: The UPS shall have the following programmable input current limit settings while operating in normal mode:
   a. Rectifier/charger input current limit shall be adjustable from 100 to 115% of UPS kW rating.
   b. Battery input current limit shall be adjustable from 0 to 16.5A per 50 kW UPM module. This limit may be extended to 29.3A for loads less than 80%.

6. On generator input current limit: The UPS shall have the following programmable input current limit settings while operating in normal mode on generator:
   a. Rectifier/charger input current limit shall be adjustable from 100% to 115% of UPS full load kW rating.
   b. Battery recharge input current limit shall be adjustable from 0 to 16.5A per 50kW UPM module. This limit may be extended to 29.3A for loads less than 80%.

7. Input current total harmonic distortion (THD) shall be less than 3% at nominal line voltage and 5% nominal source impedance.
8. Power walk-in: Ramp-up to full utility load adjustable from 10 amps per second to 1 amp per second.

D. Bypass input:

1. Synchronizing bypass voltage range shall be +10, -15% of average nominal input voltage.
2. Synchronizing bypass frequency range is +/- 0.5 Hz to +/-4 Hz, user adjustable, and is centered on the nominal frequency. Default setting is +/- 4 Hz.
3. Slew rate: 0.8 Hz per second, maximum.
4. Bypass and rectifier inputs can be supplied from out of phase sources if required.

5. Input surge withstand capability: The UPS shall be in compliance with IEEE 587 (ANSI C62.41), category A & B (6kV).

E. Rectifier/charger output:

1. Nominal DC voltage shall be 432 or 480 VDC (open circuit battery voltage). For 4-wire models, nominal DC voltage shall be 480 VDC (open circuit battery voltage).
2. Capacity: The rectifier/charger shall support a fully loaded inverter and recharge the battery to 90% of its full capacity within 10 times the discharge when input current limit is set at maximum.
3. Low line operation: The rectifier/charger shall be capable of sharing the DC load with the battery when the input voltage falls below the specified operation input voltage range, the “on battery” indicator shall annunciate operation in this mode.
4. DC sensing: DC voltage sensing methods shall be incorporated for providing battery over-voltage protection.
5. Battery charger characteristics: The UPS battery charging system shall have the following characteristics:
   a. The charger shall be capable of being configured for several charge modes including:
      1) A charging mode that increases battery life by allowing the battery to rest, reducing positive plate corrosion
      2) A charging mode floating the battery at a set level, which can be adjusted via software.
   b. UPS module will automatically adjust battery shutdown based upon loading and battery capacity.
      1) The UPS module shall automatically adjust the final discharge voltage between 1.67 and 1.75 Volts per cell based on the existing load and the rate and length of discharge.
      2) The absolute minimum operational voltage is 1.67 V per cell (adjustable upward).

F. UPS output in normal mode

1. For 3-wire models, nominal output voltage 480V, 3-phase, 3-wire plus ground at the UPS output terminals, or 4 wire plus ground at the output of the IAC-D cabinet with 208V output transformer. Output wiring configuration is based upon input wiring configuration for systems without transformers. For 4-wire models, nominal output voltage 480/277V, 3-phase, 4-wire plus ground at the UPS output terminals.
2. Steady-state voltage regulation (in inverter) shall be within +/- <1% average from nominal output voltage.
3. Transient voltage response shall be per EN62040-3, Class 1, VFI-SS-111.
4. Transient voltage recovery shall be compliant to EN62040-3, Class 1, VFI-SS-111.
5. Linear load harmonic distortion capability: Output voltage THD of less than 1% for 100% linear load.
6. Non-linear load harmonic distortion capability: Output voltage THD of less than 5% for 100% non-linear load when tested using the non-linear load described in IEC 62040-3.
7. Line synchronization range shall be +/- 4Hz, adjustable to+/-0.5 Hz.
8. Frequency regulation shall be +/- 0.1Hz free running.
9. Frequency slew rate shall be 0.8 Hz/second maximum (adjustable).
10. Phase angle control:
    a. Balanced linear load shall be <1 degree from nominal 120 degrees

11. Phase voltage control:
    a. Balanced linear loads shall be +/- 1% from average phase voltage

b. Unbalanced linear loads shall be less than <2% from average phase voltage for 100% load unbalanced

12. Overload current capability (with nominal line and fully charged battery, non-paralleled systems):
    a. Double Conversion mode: The unit shall maintain voltage regulation for 102% to <110% of resistive/inductive load for 10 minutes, 111% to <125% for 60 seconds, and 126% to 150% for 10 seconds, >151% for 300ms.
    b. Stored energy mode (typically on battery): The unit shall maintain voltage regulation for 102% to <110% of resistive/inductive load for 10 minutes, 111% to <125% for 60 seconds, and >126% for 300ms
    c. Energy Saver System operation: Continuous = 110%. Transient = 1000% peak current for 10ms.
    d. On bypass (single UPS systems): Continuous = 125%. Transient = 1000% peak current for 10ms.

13. Fault clearing current capability: See section 12 above.
14. Static transfer time, inverter to bypass: No break, completed in less than 4ms.
15. Static transfer time, Energy Saver to inverter: No break, completed in less than 4ms maximum, typically <2ms.
16. Common mode noise attenuation:
    a. -65dB up to 20kHz, -40db up to 100kHz
    b. > 100dB with isolation transformer

17. Acoustical noise: Noise generated by the UPS under normal operation shall not exceed 65dbA at one meter from any operator surface, measured at 25 degrees C (77 degrees F) and full load, per ISO 7779 standard.
18. EMI Suppression: The UPS shall meet FCC rules and regulation 47, part 15, for Class A devices, CISPR22, and IEC62040-2 C2 and C3.
19. Electrostatic discharge (ESD): The UPS shall meet IEC61000-4-2 level 3; 4kV contact/8kV air discharge.
20. Efficiency: The UPS incorporate 3-level power converter design for highest possible efficiency. Full load efficiency for non-derated hardware shall be up to 97%, 50% load efficiency shall be 96.5%, and the UPS shall achieve >95.0% efficiency at 25% load. These numbers are for N+0 configurations only.

2.6 MECHANICAL DESIGN

A. Enclosures: The UPS shall be housed in free-standing double front enclosures (safety shields behind doors) equipped with casters and leveling feet. The enclosures shall be designed for computer room applications. Front doors shall have locks to prevent unauthorized entry.

B. Modular construction: The UPS shall be comprised of Universal Power Modules (UPMs), each hardware-rated for 50kW, and each including the rectifier, inverter, and battery converter power and control circuitry. These UPMs shall be draw-out assemblies that can be quickly exchanged or replaced as necessary.

C. Ventilation: The UPS and shall be designed for forced-air cooling. Air inlets shall be on the front of the unit. Air outlet configuration for the UPS, and its accessory cabinet(s) shall be user selectable at time of order to exhaust warm air at the top of the cabinet (row or wall installations), or exhaust at the rear of the cabinet for “hot aisle” configurations. Eighteen inches of clearance over the UPS outlets shall be required for proper air circulation (top exhaust), or

working space (rear exhaust). An air filter shall be mounted in the front door of the UPS module.

D. No back or side clearance or access shall be required for the system. The back and side enclosure covers shall be capable of being located directly adjacent to a wall.

E. Cable entry: Standard cable entry for the 50/100/150kW frame UPS cabinet shall be through the enclosure bottom. Top cable entry shall be facilitated by a sidecar which can be mounted on either side of the 50/100/150kW frame UPS.

F. Front access: All serviceable subassemblies shall be modular and capable of being replaced from the front of the UPS (front access only required). Side or rear access for installation, service, repair, or maintenance of the UPS system shall not be required.

G. Service area requirements: The system shall require no more than thirty six (36) inches of front service access room and shall not require side or rear access for service or installation.

2.7 CONTROLS AND INDICATORS

A. Microprocessor controlled circuitry: The UPS controls shall have the following design and operating characteristics:

1. Fully automatic operation of the UPS shall be provided through the use of microprocessor controlled Digital Signal Processing. Start-up and transfers shall be automatic functions and will not require operator intervention.

B. Digital Front Panel Display: The UPS control panel shall be a 7” touch sensitive, backlit LCD front panel display that includes LED indicators for basic UPS status. Large, luminous, color-coded LED pillars (vertical bars) shall show the UPS status (green, amber, red), and be visible up to 30m from the UPS. The LCD shall display:

1. UPS status (home screen): the LCD screen shall have a color coded border (header) that turns red on alarm, and shows basic UPS status in the header of the display, visible at all times. The header shall alternately show UPS status output voltage and battery time remaining and be visible constantly in all display screens. The home screen shall show load level, average efficiency, and power consumption in kWh. The home screen shall show a system mimic diagram with a color-highlighted power path, operating mode, and active events.
2. Controls tab: Shall provide touch sensitive button controls, with a confirm prompt, for turning the UPS on and off, transfer to/from bypass, and enabling or disabling the battery charger, initiating a battery test, and enabling or disabling Energy Saver System (ESS).
3. Metering tab: The metering screen shall show voltages currents, temperatures, kW, kVA, and power factor (as applicable) for the UPS input, output, bypass source, and battery. Color coded (green, amber, red) bar graph indicators will accompany power and temperature measurements
4. Logs tab: alarm/event queue, active alarms and alarm history, events, status changes and commands, all timed to the 1/1000th second for tracking and analysis.
5. Statistics tab: Numerically and graphically displays the estimated savings afforded by ESS operation over time.

C. Control Panel Lamp Indicators: The UPS control panel shall provide the following monitoring functions with indicator (icon) LED’s:

1. NORMAL: This green LED shall indicate that the commercial AC utility or generator source is supplying power to the rectifier and the inverter is supporting the critical load.
2. BYPASS: This amber LED shall indicate that the UPS has transferred the load to the bypass circuit.
3. BATTERY: This amber LED shall indicate that the commercial AC utility or generator source has failed and the battery is supplying power to the inverter, which is supporting the load.
4. ALARM: This red LED and the accompanying audible alarm horn, shall indicate that the UPS detects an alarm condition, outlined in detail in the Logs tab from the home screen and in the operator's manual.

D. Interface panel: The UPS shall be equipped with an interface panel, located behind a protective cover, which provides the following signals and communication features in a Class 2 environment:

1. Alarm contact: A dry contact for annunciating a summary alarm shall be provided for customer use. This contact shall be Form "C" capable of supplying both N/O and N/C contacts. Contact ratings shall be 5A max at a voltage not to exceed 28VDC or 277VAC.
2. RS232 (EIA / TIA-232) and USB communications interfaces: Circuitry shall be provided for one "host", and one "device" USB connector, and one RS232 (EIA / TIA-232) communication port for connection to automated service department diagnostic tools. This port may be used with simple ("dumb") terminals to gain remote access to all unit operation information.
3. Building alarms: Five inputs shall be provided for monitoring the status of external dry contacts. Building alarms shall be set up through the UPS configuration mode function on the UPS front panel display or via the RS232 (EIA / TIA-232) port.
4. External Remote EPO contacts: Shall be provided to connect an external remote emergency power off switch to shut down the UPS and de-energize the critical load. Normally open or normally closed contacts shall be acceptable.
    a. The UPS remote EPO contacts shall be wired to shut down the UPS and trip the battery shunt trip on activation of the remote EPO and also on activation of the Clean Agent System.
    b. The activation of the remote EPO and the clean agent system shall also trip the UPS supply shunt trip and the CRAC unit shunt trips.
    c. Coordinate voltage and amperage requirements in the field and provide all necessary hardware, relays, wiring, etc. to accomplish the UPS shut down.
5. Battery control contacts: Contacts shall be provided to connect the battery shunt trip and auxiliary contact signals from a battery breaker or battery disconnect switch.
6. External bypass indicator connection: A connection point shall be provided to acknowledge that an external maintenance bypass has been closed around the UPS, placing the critical load on utility power.

2.8 COMMUNICATIONS

A. Communications Bay: The UPS shall be equipped with field configurable communications bays that will accommodate four (4) plug-in communication devices

B. Remote Monitoring:

1. WEB/SNMP communication capabilities will be available for all systems.
2. The UPS shall be able to be monitored remotely via communications devices. UPS manufacturer shall provide optional communications devices capable of communicating

via various industry standard protocols such as RS232, SNMP, BACnet and ModBus. Monitoring of UPS status may also be performed through isolated dry contact Form C relays.

C. Shutdown:

1. There shall be a mechanism that provides graceful, orderly, unattended, sequential shutdown of one or multiple computers powered by one UPS. This shutdown shall be performed via in-network or out-of-network means. The order of shutdown shall be user-defined, allowing the maximization of runtime on battery for more critical systems.
2. The UPS shall also be capable of interfacing with an operating system's built-in shutdown routine. This shall be done through a cable connection to the communication interface card.

D. Notification:

1. There shall be a mechanism to send alerts to key personnel via email or SNMP traps. An alarm notification may also be sent by a network message.

2.9 UPS MODULE PROTECTION

A. Rectifier/Charger and Bypass protection shall be provided through individual fusing of each phase.

B. Battery protection shall be provided by thermal-magnetic molded-case circuit breakers in each battery cabinet (if standard battery pack is provided) or external protective device for an external battery.

C. Electronic current limiting circuitry and fuses in the Inverter circuit shall provide output protection.

D. To comply with agency safety requirements, the UPS module shall not rely upon any disconnect devices outside of the UPS module to isolate the battery cabinet from the UPS module.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

3.2 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup checks according to the approved manufacturer's written instructions.

C. Factory start-up shall be provided on a 5x8 basis (7 x 24 optional). Start-up service shall be provided at no extra charge and shall include one visit to perform all procedures and tests specified within UPS Installation and Operation manual. UPS manufacturer shall also offer the following optional services:

1. Pre-energize visit to inspect installation and provide guidance to installers as required.
2. Post-start-up visit for alarm notification configuration, operator training, generator testing, etc.

D. The following procedures and tests shall be performed by Field Service personnel during the UPS startup:

1. Visual Inspection:
   a. Visually inspect all equipment for signs of damage or foreign materials.
   b. Observe the type of ventilation, the cleanliness of the room, the use of proper signs, and any other safety related factors.

2. Mechanical Inspection:
   a. Check all the power connections for tightness.
   b. Check all the control wiring terminations and plugs for tightness or proper seating.

3. Electrical Pre-check:
   a. Check the DC bus for a possible short circuit.
   b. Check input and Bypass power for proper voltages and phase rotation.
   c. Check all lamp test functions.

4. Initial UPS Startup:
   a. Verify that all the alarms are in a “go” condition.
   b. Energize the UPS module and verify the proper DC, walkup, and AC phase on.
   c. Check the DC link holding voltage, AC output voltages, and output waveforms.
   d. Check the final DC link voltage and Inverter AC output. Adjust if required.
   e. Check for the proper synchronization.
   f. Check for the voltage difference between the Inverter output and the Bypass source.
   g. Optional on site full-load, step-load, and battery discharge tests using supplier furnished load bank, shall also be offered.

5. Operational Training: Before leaving the site, the field service engineer shall familiarize responsible personnel with the operation of the UPS. The UPS equipment shall be available for demonstration of the modes of operation.

3.3 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct two 4-hour training sessions. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

End of Section

Section 26 36 00

TRANSFER SWITCHES

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SCOPE

A. Furnish and install Automatic Transfer Switches (ATS) with number of poles, amperage and voltage as shown on drawings. Withstand and Close-on ratings as listed in this specification are provided as a minimum requirement. Transfer Switches provided on this project without UL 3 cycle and 30 cycle ratings as detailed in this specification will not be reviewed or approved.

1.4 SUBMITTALS

A. Product Data: Include rated capacities, weights, operating characteristics, furnished specialties, and accessories.

1. Descriptive Literature
2. Plan, elevation, side and front view arrangement drawings, including overall dimension, weights and clearances, as well as mounting or anchoring requirements and conduit entrance locations.
3. Schematic diagrams
4. Wiring Diagrams
5. Accessory list

B. Shop Drawings: Dimensioned plans, elevations, sections, and details showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.

C. Manufacturer Seismic Qualification Certification: Submit certification that transfer switches accessories, and components will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based.

D. Field quality-control test reports.

E. Operation and maintenance data.

1.5 CODES AND STANDARDS

A. The Automatic Transfer Switches and controls shall conform to the requirements of the following :

1. UL 1008: Underwriters Laboratories Standard for Transfer Switch Equipment
2. NFPA 70 National Electrical Code
3. NFPA 99 Essential Electrical Systems for Health Care Facilities
4. NFPA 110 Standard for emergency and standby power systems
5. ANSI/IEEE 446 Recommended Practice for Emergency and Standby Power Systems for Commercial Applications
6. NEMA ICS 10 P1 Industrial Control and Systems Part 1: Electromechanical AC Transfer Switch Equipment
7. IBC-2006 International Building Code-Seismic Certified
8. UL 508 Standard for Industrial Control

1.6 CODES AND STANDARDS

A. The automatic transfer switches and controls shall conform to the requirements of:

1. UL 1008 - Standard for Transfer Switch Equipment
2. IEC 60947-6-1 Low-voltage Switchgear and Control gear; Multifunction equipment; Automatic Transfer Switching Equipment
3. NFPA 70 - National Electrical Code
4. NFPA 110 - Emergency and Standby Power Systems
5. IEEE Standard 446 - IEEE Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications
6. NEMA Standard ICS10-1993 (formerly ICS2-447) - AC Automatic Transfer Switches
7. UL 508 Industrial Control Equipment

1.7 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers

1. Russelectric
2. ASCO
3. Zenith
4. Or approved equal

2.2 BASIS OF DESIGN

A. Basis of Design product shall be Russelectric type RTS30ATB.

2.3 CONSTRUCTION

A. General

1. Transfer switches shall be electrically operated and mechanically held with double throw construction.
2. On 3 phase, 4 wire systems, utilizing ground fault protection, a true 4-pole switch shall be supplied with all four poles mounted on a common shaft. The continuous current rating and the closing and withstand rating of the fourth pole shall be identical to the rating of the main poles.
3. The transfer switch shall be mounted in a NEMA 1 enclosure, unless otherwise indicated. Enclosures shall be fabricated from 12-gauge steel. The enclosure shall be sized to exceed minimum wire bending space required by UL 1008.
4. The transfer switch shall be equipped with an internal welded steel pocket, housing an operations and maintenance manual.
5. The transfer switch shall be top and bottom accessible.
6. The main contacts shall be capable of being replaced without removing the main power cables.
7. The main contacts shall be visible for inspection without any major disassembly of the transfer switch.
8. All bolted bus connections shall have Belleville compression type washers.
9. When a solid neutral is required, a fully rated bus bar with required AL/CU neutral lugs shall be provided.
10. Control components and wiring shall be front accessible. All control wires shall be multiconductor 18 gauge 600-volt SIS switchboard type point to point harness. All control wire terminations shall be identified with tubular sleeve-type markers.
11. The switch shall be equipped with 90 degrees C rated copper/aluminum solderless mechanical type lugs.
12. The complete transfer switch assembly shall be factory tested to ensure proper operation and compliance with the specification requirements. A copy of the factory test report shall be available upon request.

B. Automatic Transfer Switch

1. The transfer switch shall be double throw, actuated by two electric operators momentarily energized, and connected to the transfer mechanism by a simple over center type linkage. Minimum transfer time shall be 400 milliseconds.

2. The normal and emergency contacts shall be positively interlocked mechanically and electrically to prevent simultaneous closing. Main contacts shall be mechanically locked in both the normal and emergency positions without the use of hooks, latches, magnets, or springs, and shall be silver-tungsten alloy. Separate arcing contacts with magnetic blowouts shall be provided on all transfer switches. Interlocked, molded case circuit breakers or contactors are not acceptable.
3. The transfer switch shall be equipped with a safe external manual operator, designed to prevent injury to operating personnel. The manual operator shall provide the same contact to contact transfer speed as the electrical operator to prevent a flashover from switching the main contacts slowly. The external manual operator shall be safely operated from outside of the transfer switch enclosure while the enclosure door is closed.

C. Transfer Switch Controller

1. The transfer switch shall be equipped with a Microprocessor Controller with a Power Supply Module, CPU and I/O Modules for all voltage and ampere ratings. The controller shall be capable of both Serial and Ethernet communications.
2. The controller shall contain voltage sensing modules capable of direct single phase or three phase sensing of each source from 120 VAC to 600 VAC. The Power Supply Module shall accept a 24 VDC external power source allowing controller communications in the event of a power outage.
3. Voltage sensing shall be true RMS type and accurate to +/- 1% of nominal voltage. Frequency sensing shall be accurate to +/- 0.05Hz. The operating temperature range shall be –20 to +50 degrees C and storage from –40 to +90 C.
4. The controller shall connect to the transfer switch through an interconnecting wiring harness. Interfacing relays shall be provided to isolate the controller from abnormal voltages applied to any and all customer input and output wiring terminals.
5. All customer interface connections shall be wired to a common DIN rail Cage Clamp terminal block. Sufficient space shall be provided to allow for future modifications and upgrades.
6. The controller shall meet or exceed the requirements for Electromagnetic Compatibility as follows:
   a. EN55022 (CISPR11) Conducted and Radiated emissions, Class B
   b. EN61000-4-2 (Level 4) ESD immunity test
   c. ENG6100-4-3 (ENV50140) Radiated RF
   d. EN61000-4-4 Electrical fast transient/burst immunity test
   e. EN61000-4-5 IEEE C62.41 Surge immunity test
   f. EN61000-4-6 (ENV50141) Conducted immunity test
   g. EN61000-4-11 Voltage dips and interruption immunity
   h. IEEE 472 (ANSI C37.90A) Ring wave immunity

D. Controller Display and Keypad

1. A color, ¼ VGA minimum, graphical display shall be provided for viewing data and setting operational parameters. Parameters shall also be available for viewing remotely and limited control through a front accessible USB communications port.
2. The Controller shall provide high intensity LED’s for the following:
   a. Source Availability - Indicates the source voltage and frequency are within preset parameters.
   b. Source Connected - Indicates the source main contacts closed and the load being served from the source.
   c. XFER Inhibit - Indicates that the ATS is being inhibited from Automatic operation to the unconnected source.
   d. Alarm – Indicates an alarm condition is active.

e. TD Active – Indicates that a transfer switch time delay is actively timing.

3. For ease of navigation, the display shall include the following:
   a. Soft Keys – Change function based on user location in the menu structure.
   b. Dedicated Navigational Keys – Home, Scroll Up, End, Escape and Enter.
   c. Dedicated Pushbuttons for Alarm Reset, Test, Control and Information.

2.4 OPERATION

A. Voltage, Frequency and Phase Rotation Sensing

1. Programmable voltage and frequency sensing of both sources capable of detecting single or three phase losses. The Controller shall have adjustable pickup and dropout settings for each source. Set point ranges as follows:

Parameter	Sources	Dropout/Trip	Pickup/Reset
Undervoltage	N+E, 3phase	72 to 100%	70 to 98%
Overvoltage	N+E, 3phase	100 to 108%	102 to 110%
Underfrequency	N+E, 3phase	45.1 to 60.0 HZ	45.0 to 59.9 HZ
Overfrequency	N+E, 3phase	50.0 to 69.7 HZ	50.1 to 69.8HZ

2. The controller shall monitor phase rotation of both sources and inhibit transfer if both sources are not the same phase rotation. (ABC or CBA)
3. Settings shall be adjustable in 1% increments either through the keypad, USB port or remotely via communications.
4. A single source status screen shall be provided to allow for viewing of the status of both sources including three phase voltage, power and frequency.

B. Time Delays

1. The controller shall include an adjustable time delay of 0 to 10 seconds to momentarily override normal source power outages and to delay engine starting. The time delay shall be expandable up to 60 minutes if an external 24 VDC power supply is provided for ATS control.
2. The controller shall include an adjustable 0 to 60 minute time delay on transfer to emergency, factory set at 3 seconds.
3. The controller shall include a time delay on retransfer to the preferred source adjustable 0 to 259 minutes, factory set at 5 minutes.
4. The controller shall include a time delay on engine cool down adjustable 0 to 60 minutes, factory set at 5 minutes.
5. The controller shall include a timer to control the transition time from neutral to the non-preferred source, adjustable 0 to 10 minutes, factory set at 3 seconds.
6. The controller shall include a timer to control the transition time from neutral to the preferred source, adjustable 0 to 10 minutes, factory set at 3 seconds.
7. All time delays shall be adjustable in 1second increments. All time delays shall be adjustable via the graphical display, the front USB port or configuration software using the USB, serial or Ethernet communications port.

C. Additional Features

1. Test Switch – The controller shall be provided with a two position, password
2. protected, test switch to simulate a normal source failure. The test mode shall be configurable for Test Without Load or Test With Load functionality. The Test function shall be activated via the pushbutton on the display or remotely via a dry contact, voltage signal or a network signal.
3. Engine Start Signal – A SPDT contact, rated 10 amps at 30 VDC, shall be provided to start the engine generator in the event of a normal source outage.
4. Source connected contacts rated 10 amps at 120 VAC shall be provided to signal when the ATS is connected to each source.
5. Source Connected LED's – The controller shall include LED's to indicate when the ATS is connected to each source.
6. Source Availability LED's – The controller shall include LED's to indicate the availability of each source.
7. Commit/No-Commit Transfer Selector – The controller shall include a programmable selector to configure the controller to commit to transferring the load to emergency (or not) in the event the normal source returns prior to the being ready to accept load.
8. Inhibit Transfer Signals – The controller shall be capable of accepting transfer inputs that inhibit transfer of the ATS to either source.
9. Auto/Manual Selector – The controller shall include a programmable function to select either Automatic or Manual operation.
10. ATS/Engine Exerciser – The controller shall include a user configurable exerciser.
11. Exerciser shall be configurable for daily, 7 day, 14 day or 28 day exercise periods, each with (7) programmable events. The exerciser shall also be configurable as a full, 365 day exerciser with up to 24 independent exercise events. Each event shall be configurable for Test with Load and Test Without Load. Each event shall include user adjustable start time, date and test duration. All time and date settings shall be stored in non- volatile EEPROM memory. The controller shall include full programmability for daylight savings time.
12. Diagnostics – The controller shall contain self and system diagnostic screens for the purpose of detecting and troubleshooting abnormal system events.
13. Communications Interface – The controller shall be capable of interfacing via serial/RS485 or optional Ethernet TCP/IP communications ports integral to the controller. All communications parameters (baud rate, parity, IP Address, etc.) shall be accessible and programmable via the front keypad. Both serial and Ethernet communication shall be Modbus open protocol.
14. Event Logger – The controller shall have the ability to log data and to maintain the last 256 events, even in the event of a power failure. Time and date stamping of events will be accurate to 1 ms. Controller shall be capable of synchronizing it's date/time setting with a main PC via Network Time Protocol over an Ethernet TCP/IP network connection. The following events shall be time and date stamped:
    a. Last Primary Source Failure
    b. Last reason for transfer.
    c. Last transfer to alternate source
    d. Last retransfer to primary source
    e. Time load is without power
    f. Time ATS powered up
    g. Total time on source 1
    h. Total time on source 2
    i. Total number of primary source failures
    j. Total number of transfers

15. Communications Modules

a. Serial Communications: Controller shall support RS485 communications port to enable serial communications at baud rates up to and including 115.2Kbps and be user configurable. The serial communications shall be capable of a direct connect or multi-drop configured network.
b. Ethernet Communications: Controller shall be capable of supporting an optional Ethernet TCP/IP communications via an internally mounted and self powered communications card. Ethernet shall be 10/100 Mbit, auto sensing and include a RJ45 network connector.
c. Open Protocol: Both serial and Ethernet communications shall be Modbus protocol. Proprietary communications protocols shall not be acceptable.

16. External Power Supply: The controller shall be capable of being connected to an external 24 VDC power supply to permit full operation and communications of the controller when both sources are denergized.
17. Auto Load Shed: The controller shall be capable of being programmed to automatically shed the connected load in the event of a user configurable under frequency condition.
18. Customer Configurable Alarms – The controller shall be capable of being configured to display customer configured alarm points. Alarms shall be capable of being reset via a remote contact or the front panel RESET pushbutton.

D. Power Quality Metering

1. The ATS shall be able to supply optional metering for current, voltage, real power, reactive power, energy use, power factor and frequency. Metering shall be true RMS type, 1% accuracy for voltage and 0.5% for currents with a 5 amp secondary current transformer.
2. The following parameters shall be provided:
   a. Phase current: Ia, Ib, Ic, In and average current (Iavg)
   b. Phase voltage: Va, Vb, Vc, Vab, Vac, Vbc
   c. Voltage and Current unbalance
   d. Hz, PF, W, Var, VA
   e. Wh, VAh, VARh
   f. Voltage and Current Harmonics (% THD up to 8th order)
   g. Phase Rotation Sensing
   h. Synchroscope (lead/lag)

3. The ATS shall be capable of monitoring and capturing waveform data in the event of a utility power outage or other user specified event.
   a. A total of 10 active channels of waveform capture may be user configured.
   b. Each channel shall be capable of capturing up to 256 cycles of waveform information.
   c. Analog channels may be configured for 4, 8, 16 or 32 samples/cycle.
   d. Digital channels shall be configured for 1 sample/cycle.
   e. Waveform data shall be stored in industry standard COMTRADE format for broadest compatibility and ease of downloading to a PC.

E. The controller shall be capable of logging digital and analog measured parameters and storing the data in non-volatile memory.

1. The controller shall contain a 10 channel Data Logger. Each channel shall be capable of being configured to monitor a digital on/off or analog measured parameter.
2. The sampling rate of each channel shall be configurable form 1 cycle to 60 minutes per sample. The data shall be stored in non-volatile memory in a first in, first out method.

2.5 ADDITIONAL REQUIREMENTS

A. Withstand and Close Ratings

1. The ATS shall be UL listed in accordance with UL 1008 for 3 and 30 cycle close and withstand ratings. ATSs that are not tested and labeled for 3 and 30 cycle, ratings are not acceptable. Minimum UL listed close and withstand ratings at 480 VAC shall be as follows:

Size Amps	3 Cycle	30 Cycle	Current Limiting Fuses
100 – 400	42 Ka	30 Ka	200,000 Ka
600- 800	65 Ka	42 Ka	200,000 Ka
1000-1200	85 Ka	65 Ka	200,000 Ka
1600-3000	100 Ka	85 Ka	200,000 Ka
4000	125 Ka	100 Ka	200,000 Ka

2. During 3 cycle and 30 cycle closing and withstand tests, there shall be no contact welding or damage. The 3 cycle and 30 cycle test shall be performed without the use of current limiting fuses. The tests shall verify that contact separation has not occurred, and there is contact continuity across all phases. Test procedures shall be done in accordance with UL-1008, and testing shall be certified by Underwriters Laboratories, Inc.
3. When conducting temperature rise tests to UL-1008, the manufacturer shall include post-endurance temperature rise tests to verify the ability of the ATS to carry full rated current after completing the overload and endurance tests.

2.6 ATS REMOTE ANNUNCIATOR

A. General

1. Provide and install ATS Remote Annunciator for monitoring and control of automatic transfer switches remotely.
2. Furnish and install a manual start and transfer system for the emergency / standby generator that meets the requirements of the Massachusetts State Building Code at the Fire Command Center. This system shall include but not be limited to; cabinet, contacts to start, stop, transfer, and bypass the automatic transfer switch time delay, all wiring, conduits, etc. for a complete and working system that will meet all requirements of the Fire Department. Final testing shall be performed to demonstrate functionality of the system.

B. Hardware Specifications

1. The ATS Remote Annunciator shall be listed to cUL-60950-1 and UL 1008 and include the following features and ratings:
   a. User-configured labels with ATS names and power sources
   b. Dual 10/100 Base-T auto sensing and auto crossover Ethernet ports
   c. LED indication of source acceptability, switch position, common alarm, time delay and Ethernet link activity

d. Push button for transfer/retransfer control operations and time delay bypass
e. Push buttons for Alarm Silence and Lamp Test
f. Key lock to enable and disable the transfer push button
g. Audible and visual alarm to indicate Communication Error ATS Locked Out Failure to Synchronize Extended Parallel and any of the 8 user-configured discrete inputs
h. Programmable watchdog timer that can generate a system reset upon timeout (minimum 1 sec)
i. Factory reset capability
j. 100 ms power ride-through

C. Software Specification

1. The ATS Remote Annunciator shall contain embedded web pages accessible via various web browsers with the following capabilities:
   a. Configuration for protocol and communications management with the ability of auto discovering transfer switches on network
   b. Ability to create and print customized labels for ATS names and power sources
   c. The ability to choose a continuous or periodic audible alarm with customizable interval time
   d. View detailed packet status counters i.e. transmitted received and dropped packets with the ability to reset counters
   e. ATS source name configuration page which allows users to configure power source names and print labels
   f. Upgrade firmware from Ethernet network without interrupting equipment operation

D. Communications

1. Dual 10/100 Base-T (RJ-45) Ethernet ports are provided to support TCP/IP communications for up to eight automatic transfer switches via individual remote connectivity modules or daisy-chained serial modules into a single Connectivity Module. Additional features shall include:
   a. Supports Full Duplex Flow Control (IEEE 802.3x)
   b. 3.3V power supply with 5V I/O tolerance
   c. Supports 3 LEDs to indicate traffic link speed and collision

E. Mounting

1. The ATS Remote Annunciator is suitable for:
   a. Surface mounting using mounting screws studs
   b. Flush Mount from behind a cutout section (Enclosure Door Mounting)
   c. Flush Mount from the front of a cutout section (Enclosure Door Mounting)

F. Power Supply

1. The ATS Remote Annunciator shall be capable of accepting 24VDC, 120 VAC or
2. 240 VAC power source.

G. Environmental

1. The ATS Remote Annunciator shall have an Ambient Operating Temperature range of -4 º to 158 º F (-20 º to +70 º C) @ 5~85% humidity and Ambient Storage Temperature of -40 º to 185 º F (-40 º to 85 º C).

PART 3 - EXECUTION

3.1 INSTALLATION

A. Design each fastener and support to carry load indicated by seismic requirements and according to seismic-restraint details. See Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

B. Floor-Mounting Switch: Anchor to floor by bolting.

1. Concrete Bases: 4 inches (100 mm) high, reinforced, with chamfered edges. Extend base no more than 4 inches (100 mm) in all directions beyond the maximum dimensions of switch, unless otherwise indicated or unless required for seismic support. Construct concrete bases according to Division 26 Section "Hangers and Supports for Electrical Systems."

C. Identify components according to Division 26 Section "Identification for Electrical Systems."

D. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

3.2 CONNECTIONS

A. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.3 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections. Report results in writing.

1. The Transfer Switch manufacturer shall employ a nationwide factory-direct, field service organization, available on a 24 hours a day, 365 days a year call basis.
2. The manufacturer shall include an 800-telephone number, for field service contact, affixed to the outside of each enclosure.
3. The manufacturer shall maintain records of each transfer switch, by serial number, for a minimum of 20 years.

B. Perform tests and inspections and prepare test reports.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installation, including connections, and to assist in testing.
2. After installing equipment and after electrical circuitry has been energized, test for compliance with requirements.
3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

4. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Use test voltages and procedure recommended by manufacturer. Comply with manufacturer's specified minimum resistance.
   a. Check for electrical continuity of circuits and for short circuits.
   b. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
   c. Verify that manual transfer warnings are properly placed.
   d. Perform manual transfer operation.

5. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
   a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
   b. Simulate loss of phase-to-ground voltage for each phase of normal source.
   c. Verify time-delay settings.
   d. Verify pickup and dropout voltages by data readout or inspection of control settings.
   e. Perform contact-resistance test across main contacts and correct values exceeding 500 microhms and values for 1 pole deviating by more than 50 percent from other poles.
   f. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.

6. Ground-Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.
   a. Verify grounding connections and locations and ratings of sensors.

C. Coordinate tests with tests of generator and run them concurrently.

D. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

E. Remove and replace malfunctioning units and retest as specified above.

F. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.

1. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
2. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.4 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup check according to the approved manufacturer's written instructions.

3.5 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct four 4-hour training session. Train the Owner's maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

End of Section

Section 26 41 13

LIGHTNING PROTECTION FOR STRUCTURES

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. Scope of Work includes:

1. Early streamer emission (ESE) lightning protection system for the building.

B. Related Work of other Sections:

1. Roof flashing.
2. Non-metallic conduit.
3. Surge Suppression.
4. Grounding.

1.4 QUALITY ASSURANCE

A. Codes: Comply with the Building Code of the State and standards listed.

B. Standards:

1. Underwriters Laboratories Inc.
   a. UL 96

2. Manufacturer’s Installation Standard
   a. HBP-21

3. The lightning protection system shall be designed by the engineering staff of the manufacturer of the equipment proposed to be installed.

C. Qualifications:

1. Installer's Qualifications:
   a. The installation shall be made by or under the supervision of a licensed electrical contractor.

D. Certification:

1. Applied Research Laboratories (ARL) shall certify that the lightning protection system has been installed in accordance with the design and specification requirements.
   a. Applied Research Laboratories Inspection. Send completed ARL Certification Application Form to:
      1) Applied Research Laboratories, 5371 N. W. 161st Street, Miami, FL 33014
      2) Correction of Work: Areas indicating non-conformance with Manufacturer's Installation Standard HBP-21 shall be corrected by the installing contractor at no additional cost to the owner.
      3) After completion of ARL inspection and acceptance, provide the owner with ARL Certification, Manufacturer's guarantee, warranty and $10,000,000 insurance coverage.

E. Testing:

1. A resistance-to-ground test of the completed system shall be performed using IEEE "Fall of Potential Method".
   a. Resistance-to-ground reading shall not exceed 10 ohms.

1.5 SUBMITTALS

A. Submittal Package: Complete shop drawings showing the type, size and locations of all equipment, grounds and cable routings shall be submitted to the architect for approval prior to start of work.

B. Submit shop drawings and product data as specified below.

1. Shop Drawings: Detailed scale drawings of the complete system as proposed to be installed.
2. Product Data:
   a. Catalog cut sheets and installation instructions
   b. Bill of materials

1.6 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Manufacturers

1. Heary Bros. Lightning Protection Co. Inc.
2. Lightning Preventor of America.
3. Thompson Lightning Protection, Inc.
4. Or approved equal.

B. All materials for this installation shall be as defined by Underwriters Laboratories UL 96.

C. Copper shall be of the grade ordinarily required for commercial electrical Work, generally designated as being 98 percent conductivity when annealed.

1. Copper components shall not be used on aluminum surfaces.

D. Air terminal:

1. Early Streamer Emission (ESE) air terminal
   a. 5/8" x 12" chrome plated copper
   b. Chrome plated copper support structure and sphere
   c. Threaded air terminal

E. Conductors:

1. Copper Cable
   a. Copper 28 strands of 14 gauge copper ropelay wire, 115,000 circular mils, weighing not less than 375 lbs. per 1000 ft.
   b. The structural steel may be used in lieu of down conductors.
      1) Every other column or an average of 60'-0" intervals shall be bonded and connected to the ground system.

F. Attachments:

1. Fasteners shall be of suitable configuration for the intended application and of the same material as the conductor. Nails, screws or bolts employed to secure the fasteners shall be stainless steel.

G. Connections and Splices:

1. Connectors and splices shall be of suitable configuration and type for the intended application and of the same materials as the conductor.

H. Ground Rods:

1. 3/4" x 10'-0" copper-bond ground rods with two-bolt copper ground rod clamp.
2. One delta ground grid shall be installed for each down conductor.
3. 24" x 24" x 20 gauge copper ground plates may be used in lieu of ground rods if soil conditions do not allow driving of ground rods.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install the lightning protection system as required to obtain ARL certification.

B. The system shall consist of a mast-type system on the highest roof. The system shall include air terminal, mast, grounding cable, ground rods and splices.

C. Cables on roof shall be exposed and shall be fastened every 3'-0" max.

D. Downlead cables to ground rods shall be in 1" non-metallic conduit concealed within building construction.

E. Downlead cables shall not be brought directly through the roof. Conduit through pitch pockets or proper roof flashings shall be utilized for this purpose.

F. The roofing contractor shall furnish and install all proper roof flashings.

G. The electrical contractor shall furnish and install all necessary conduit for concealed down conductors.

H. Copper components shall not be connected to aluminum surfaces except by means of a bimetal connector.

I. Bond lightning protection system to the electrical system ground with 3/0 Copper grounding conductor.

3.2 COORDINATION

A. The lightning protection installer shall work with other trades to insure a correct, neat and unobtrusive installation.

B. A sound bond shall be made to the main water service, and to all other building grounding systems, including both telephone and electrical.

C. Proper surge arresters shall be installed on the power and telephone service by either the utility or the electrical contractor, as applicable.

1. Install surge arresters on electric service entrance secondary conductors.

D. The installing contractor shall provide a videotape of the installation, including but not limited to; air terminal, mast mounting, bonding connections (waterline & structural steel), down conductors, ground rods/grids, test results and all buried, concealed or inaccessible connections and components.

1. The videotape and resistance-to-ground test results shall be forwarded to the lightning protection system manufacturer for review.
2. Upon completion of the installation, ARL shall inspect the installation (via videotape) for compliance with Manufacturer's Installation Standard HBP-21.

End of Section

SECTION 26 50 00

THEATRICAL LIGHTING CONTROLS AND FIXTURES

(Part of the Work of Section 260001 – Electrical Trade Bid)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

B. Examine all other Sections of the Specifications for requirements that affect work of this Section whether or not such work is specifically mentioned in this Section.

C. Coordinate work with that of all other trades affecting or affected by work of this Section. Cooperate with such trades to assure the steady progress of all work under the Contract.

1.2 EXAMINATION OF SITE AND DOCUMENTS

A. Bidders are expected to examine and to be thoroughly familiar with all contract documents and with the conditions under which work will be carried out. The Awarding Authority (Owner) will not be responsible for errors, omissions and/or charges for extra work arising from Construction Manager or Electrical Trade Contractor's failure to familiarize themselves with the Contract Documents or existing conditions. By submitting a bid, the Bidder agrees and warrants that he has had the opportunity to examine the site and the Contract Documents, that he is familiar with the conditions and requirements of both and where they require, in any part of the work a given result to be produced, that the Contract Documents are adequate and that he will produce the required results.

1.3 SUMMARY

A. The work of this section includes all labor, materials, equipment and services required for the manufacture, delivery, coordination and installation of performance lighting control and distribution systems as indicated on the Drawings and schedules.

B. Section Includes
   1. Engineering, manufacture, furnishing, coordination and commissioning of performance lighting dimming and control system including, but not limited to, the following:
      a. Dimmer modules
      b. Over-current protected motorized circuit breaker panels
      c. Distribution faceplates and devices
      d. Control faceplates and devices
      e. Control console and accessories
      f. System accessories
      g. Configuration of system
      h. Coordination and addressing of architectural lighting fixtures
      i. User training

C. Products Controlled but not Provided Under This Section
   1. Architectural Lighting Fixtures

D. Products Supplied But Not Installed Under This Section

1. Products installed by the Electrical Trade Contractor
   a. Switched power and control distribution including connectors strips and faceplates
2. Product not requiring installation
   a. Lighting fixtures and accessories

1.4 RELATED WORK SPECIFIED ELSEWHERE

A. Carefully examine all of the Contract Documents for requirements which affect the Work of this Section.

B. Other Specification Sections which directly relate to the Work of this Section include, but are not limited to, the following:
1. Section 01 00 00 - General Requirements
2. Section 04 20 00 - Unit Masonry
3. Section 06 40 20 – Interior Architectural Woodwork
4. Section 07 84 10 - Penetration Firestopping
5. Division 26 – Electrical
   a. Reference Division of responsibility matrix on Drawings.
6. Division 27 - Communications; including all Sections contained therein
   a. Section 27 41 16 – Integrated Audiovisual Systems

1.5 REFERENCES

A. National Fire Protection Association (NFPA)
1. NFPA70 - National Electrical Code
2. NFPA 110 – Standard for Emergency and Standby Power Systems

B. American National Standards Institute (ANSI)
1. E1.11-2004 - USITT DMX512-A
2. E1.17-2006, Entertainment Technology – Multipurpose Network Control Protocol Suite (ACN)
3. E1.20-2006, Entertainment Technology – Remote Device Management over USITT DMX512
4. E1.27-1-2006, Entertainment Technology – Standard for Portable Control Cables for Use with ISUTT DMX512/1990 and E1.11 Products

C. Institute of Electrical and Electronics Engineers (IEEE)
1. 802.3 – Ethernet
2. 802.11 – Wireless LAN

D. Underwriters Laboratories (UL)
1. 498 – Attachment Plugs and Receptacles
2. 891 - Switchboards
3. 924 – Emergency Lighting and Power Equipment
4. 1008 – Transfer Switch Equipment

1.6 DEFINITIONS

A. Furnish – Purchase and/or fabricate the item and deliver to site.

B. Install – Perform the physical installation of the item on the site.

C. Provide – Furnish and install item or items, complete with any and all required accessories.

1.7 SUBMITTALS

A. Provide submittals in accordance with requirements of Division 01 – General Requirements.

B. Qualifications
   1. Manufacturer shall have been continuously engaged in the design and manufacture of performing lighting dimming and control equipment for at least ten (10) years.
   2. Bidder shall be a theatrical lighting system contractor, normally engaged in the full time business of lighting system installation. Provide evidence that the bidder has been in business for at least five years prior to bid date and has completed projects of similar size and scope.
   3. References, including names and telephone numbers of individuals who may be contacted, showing satisfactory completion of five or more projects similar in scope and type to that specified herein.
   4. Evidence of ability and affirmation of intent to meet the guarantee and service requirements stated herein.
   5. Each vendor shall include a description of the professional and technical experiences background, qualifications and expertise of the organization's key personnel assigned to this project. The description shall show that bidder possesses the demonstrated skills and experience in specific areas of the project scope. In addition, Bidder shall identify a project manager for the project and shall provide resumes of all personnel who shall be assigned to this project. Bidder shall estimate the percentage of time each individual shall be working on this project.

C. Product Data
   1. Submit complete Bill of Materials including spare parts, quantities, manufacturer and model numbers.
   2. Submit manufacturer's catalog cut sheets for all products used in the system.

D. Shop Drawings
   1. Submit 11" x 17" sheets. All sheets shall be the same size. Include title sheet listing all drawings in the submittal.
   2. Show all assembly instructions, termination details, cable numbers and other information required to ensure proper installation of the equipment.
   3. Show all materials, finishes, metal gauges, dimensional information, electrical and mechanical connections, provision for work by others and related information.
   4. Provide drawings showing wiring, addressing and termination scheme for architectural lighting fixtures.
   5. Indicate deviations from this Specification and label with minimum 1/4" high text: "Variation from Spec."
   6. Revise drawings with changes marked on the reviewed submittal and any changes made during manufacturing or due to coordination with other trades. Send a revised shop drawing to Architect at the time of the first delivery of equipment.
   7. Installation of equipment shall not begin until shop drawings have been approved by the Architect.
   8. Touch panel layouts.

E. Quality Assurance/Control
   1. Submittals
      a. Verify wire type, count and routing for all low-voltage wiring between components.
      b. Confirm conduit sizes and routing within 30 days of contract award.
   2. Test Reports
      a. Prior to scheduling a final checkout the Manufacturer's field technician shall submit to the Architect a letter stating that the system has been installed correctly is fully operational.

F. Closeout Submittals
1. Prepare and submit complete Operations and Maintenance Manuals in accordance with the requirements in Division 1.
2. Submit one (1) bound set to the Architect for review. Make revisions as directed by the Architect and submit revised manual as follows:
a. Three (3) bound sets to the Owner
b. One (1) bound set to the Architect.
3. Operations and Maintenance Manual shall contain:
a. As-built shop drawings showing all systems, interconnections and components as installed.
b. Operating instructions for all equipment
c. Compiled list of all periodic maintenance required for all components of the system
d. Printed copy of initial system configuration
e. Warranty information
f. Emergency and regular technical support telephone contact information.
g. CD or DVD with all applicable software, system configuration information and maintenance and instruction manuals

1.8 QUALITY ASSURANCE

A. All work and materials in this section shall comply with the following:
1. National Electrical Code NFPA 70
2. Applicable state and local construction codes
3. Tested by a Nationally Recognized Testing Laboratory such as UL or ETL.

B. Pre-installation Meetings
1. Attend coordination meetings as required to ensure installation is coordinated with other trades.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Delivery, storage and handling shall be coordinated with the Electrical Trade Contractor and meet all the requirements set forth in Division 1.

B. Packing, Shipping, Handling, and Unloading
1. Securely package all equipment in factory fabricated wooden or cardboard containers for delivery.
2. Package and handle all equipment to prevent breakage, denting and scratching of finishes. Damaged equipment shall not be installed. Replace with new units from manufacturer.

C. Storage and Protections
1. Store all equipment in a substantially complete, “broom clean”, secure and conditioned space.
2. Store all equipment in its original packaging until installation.

1.10 WARRANTY

A. Warranty Period Commencement Date: Effective stating date for Warranty periods is the Date of Substantial Completion for Project as listed under Section 01 12 00 Project Phasing.
1. Equipment and systems start-up, operation, and use, occurring prior to Project Substantial Completion, will not be considered commencement of warranty period under any terms of this Contract.
2. Exceptions: Starting dates for warranties prior to the Project Date of Substantial Completion are not permitted, except for the two conditions below:

a. Warranty requirements specified in individual specification sections explicitly specify that a required warranty or guarantee shall be effective on date of shipment, date of manufacturer, or date of installation.
b. Warranties for Incomplete work: The effective date for warranty of work which has not been completed prior to the Date of Substantial Completion, shall be effective on the date of the Owner's acceptance of the Work.
c. This project has two substantial completions, the first for the building and site surrounds, Phase 2. The second for the Parking and Field work, Phase 3 and 4 Refer to PROJECT PHASING REQUIREMENTS Section 01 12 00
d. Provide theatrical LED Ellipsoidal and Wash Fixtures with 5-year full fixture warranty and 10-year LED array warranty.

B. During the warranty period repair or replace defective items within ten business days of the defect being reported. If temporary replacement equipment is required, it shall be provided to the Owner at no cost.

C. Correct conditions that could present a safety hazard within forty-eight hours of notification.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. The following are the acceptable manufacturers or systems integrators for the primary switching and control components of the system:
1. Electronic Theatre Controls (ETC)
3031 Pleasant View Road
Middleton, WI 53562
800.688.4116
www.etcconnect.com
2. Strand Lighting
6603 Darin Way
Cypress, CA 90630
714.230.8200
www.strandlighting.com
3. Wenger | JR Clancy
555 Park Drive
Owatonna, MN 55060
800.493-6437

2.2 CONTROL WIRE

A. Provide all control wiring per manufacturer requirements.

B. Architectural Control Station
1. Electronic Theatre Controls
a. Belden 8471, One #14 AWG stranded, Two #16 AWG
2. Strand
a. Belden 1583A, Two #14 AWG stranded

C. Ethernet
1. Belden 1583A
2. Liberty Cable Equal
3. West Penn Equal

D. DMX

1. Belden 9729
2. Liberty Cable Equal
3. West Penn Equal

2.3 ARCHITECTURAL LIGHTING PROCESSOR

A. Provide unit designed for operation with supplied motorized circuit breaker panels.

B. Provide unit with Ethernet connection to the lighting control network for configuration and control.

C. Provide unit capable of backing up settings to removable media.

D. Provide unit with two DMX ports, each of which may be configured as input or output.

E. Provide unit with 1024 channels of control.

F. Provide unit and power supplies to support all specified interface stations.

G. Provide unit with RS-232 interface to AV Control System Processor if direct Ethernet connection is not supported.

H. Provide unit that can create multiple software-defined rooms.

I. Mount unit in Lighting Control Rack.
   1. ETC Unison P-ACP w/ERn2-RM-120 enclosure
   2. Interactive Technologies CueServer 2 Pro
   3. Strand Equal

2.4 MOTORIZED CIRCUIT BREAKER PANEL

A. General
   1. Provide Ethernet-controlled AC switching panel with individual circuit over-current protection.

B. Control
   1. Control: Single universe of DMX over Ethernet
   2. Provide panel with contact-closured triggered emergency override scene recall.

C. Electrical
   1. Provide with 20A circuit breakers.
   2. Provide with main lug inputs, per Drawings.
   3. Provide with main breaker to match electrical input shown on Drawings.
   4. Provide panel with 100% neutral capacity.

D. Spares
   1. Provide 10% spare circuit breakers for each type in system.

E. Provide
   1. ETC Sensor IQ
   2. Strand equal
   3. Lyntec equal

2.5 AUDITORIUM CONTROL CONSOLE

A. Features
   1. Control Channels: 32,768
   2. DMX Channels: 12,288
   3. Cues: 10,000

4. Cue Lists: 999
5. Presets: 1,000
6. Groups: 1,000
7. Effects: 1,000
8. Macros: 1,000
9. Color paths: 1,000
10. Hard disk storage
11. USB port for storage, pointing and keyboard devices
12. Hue / saturation color and gel picker color mixing
13. On-screen magic sheets
14. RDM enabled
15. Motorized faders: 20

B. Interface Options
1. Support the following local interfaces:
a. AC input.
b. Keyboard and mouse
c. Two independently configurable Ethernet ports
d. Two touch-sensitive displays

C. Physical
1. Console power shall be 95 – 240V AC at 50 or 60Hz, supplied via a detachable power cord.

D. Acceptable Products
1. ETC Ion Xe 20 – 12K
2. Strand NEO w/ submaster wing
3. Equal
a. Quantity: 1

2.6 AUDITORIUM CONTROL CONSOLE ACCESSORIES

A. Provide wi-fi based hand-held 8-inch touch panel remote in ruggedized case for use as remote control for console. Provide with wi-fi access point, desktop charging stand, hand strap, and rechargeable battery.

B. Provide keyboard, mouse, dustcover, power cord, manual.

C. Provide two 24” single-touch flat-panel LCD monitors on tilting and height-adjustable stands for console.

D. Provide 25-foot Ethernet cable and 25-foot DMX control cable.

E. Uninterruptible power supply

F. Dimmable gooseneck worklight.

2.7 BLACK BOX CONTROL CONSOLE

A. Features
1. Control Channels: 32,768
2. DMX Channels: 6,144
3. Cues: 10,000
4. Cue Lists: 1
5. Presets: 1,000
6. Groups: 1,000
7. Effects: 1,000

8. Macros: 1,000
9. Hard disk storage
10. USB port for storage, pointing and keyboard devices
11. Hue / saturation color and gel picker color mixing.
12. RDM enabled
13. Physical faders: 40

B. Interface Options
1. Support the following local interfaces:
   a. AC input.
   b. Keyboard and mouse
   c. Two independently configurable Ethernet 802.3af compliant ports
   d. Two touch-enabled displays

C. Physical
1. Console power shall be 95 – 240V AC at 50 or 60Hz, supplied via a detachable power cord.

D. Acceptable Products
1. ETC Element 2 - 6K
2. Strand Equal
   a. Quantity: 1

2.8 BLACK BOX CONTROL CONSOLE ACCESSORIES

A. Provide wi-fi based hand-held 8-inch touch panel remote in ruggedized case for use as remote control for console. Provide with wi-fi access point, desktop charging stand, hand strap, and rechargeable battery.

B. Provide keyboard, mouse, dustcover, power cord, manual.

C. Provide two 24” single-touch flat-panel LCD monitors on tilting and height-adjustable stands for console.

D. Provide 25-foot Ethernet cable and 25-foot DMX control cable.

E. Uninterruptible power supply

F. Dimmable gooseneck worklight.

2.9 ARCHITECTURAL CONTROL PANELS

A. Entry Panel (EP)
1. Provide control station per drawings for installation in a one-gang electrical box.
2. Provide back box for surface mount locations.
3. Provide in finish per schedule.

B. Fader Panel (FP)
1. Provide twelve-button, seven-fader control station for installation in a four-gang electrical box or rack panel.
2. Provide back box for surface mount locations.
3. Provide rack panel for rack-mount locations.
4. Provide in finish per schedule.
5. Custom legend per Drawings.

C. Touch Panel (TP)
1. Provide 7-inch touch panel for installation in custom back box or rack panel.
2. Provide back box for surface and flush mount locations.

3. Provide rack panel for rack mounted locations.

2.10 NETWORK COMPONENTS

A. Ethernet Switch
   1. Provide managed network switch as required for operation of the network system. Provide switches with the following properties:
      a. Twenty-four (24) managed dual speed auto-sensing ports supporting 1000BaseT, 100BaseT and 10Base-T.
      b. All ports on the switch shall provide Power Over Ethernet.
      c. Support for multicast Ethernet
      d. IGMP snooping compatible
      e. Mount in standard 19 inch equipment rack.
      f. Acceptable Manufacturers:
         1) Cisco
         2) HP
         3) Pakedge

B. Ethernet Patch Bay
   1. Provide Category 5e patch bay as required for termination of all lighting network UTP runs in the equipment rack.
   2. Provide patch cords as required for connection to the Ethernet Switch.
   3. Mount patch bay in standard 19” equipment rack.

C. Cable Management
   1. Provide rack-mounted brush-type cable management.
   2. Mount unit between Ethernet switch and Ethernet patch bay.

2.11 CONTROL DEVICES

A. General
   1. Provide back boxes for all surface and pipe mounted devices and all devices that will not fit in a standard electrical gang box.
   2. Provide all required mounted hardware for surface and pipe mounted back boxes.
   3. Label back boxes and faceplates with unique designations printed on removable adhesive labels to correspond to shop drawings.

B. Portable One-Port Ethernet Node
   1. Ethernet node shall translate Ethernet-based control protocol into DMX-512.
   2. Node shall be powered via its Ethernet connection using Power Over Ethernet.
   3. Provide 10’ Category 5e rough service extension cable with Neutrik Ethercon connectors with each node.
   4. Provide 5’ long male to male turnaround XLR-type cable to allow node to be used as DMX input.
   5. Provide node with c-clamp for mounting to pipe.
      a. Quantity: 4

C. Portable House Lighting Console
   1. Provide portable lighting control station in table-top enclosure with 7-inch touch panel.
   2. Provide with 15-foot permanently attached cable with hard service connector.
   3. Provide in finish per Architect selected from manufacturer’s full range of standard finishes.
      a. Quantity: 2

D. Ethernet Node, Eight Port (E8)
   1. Ethernet node shall translate Ethernet-based control protocol into DMX-512/RDM.
   2. Provide node with eight rear-facing DMX outputs.

3. Provide with rack-mount hardware.

E. DMX Bypass Unit, Single Channel
1. Provide UL924 listed DMX controller to trigger “full-on” for emergency LED architectural fixtures on contact closure trigger. Provide unit with single DMX output.
2. Provide with restore switch.
   a. ETC DEBC-1
   b. Strand Equal

F. DMX Bypass Unit, Multi-Channel
1. Provide UL924 listed DMX controller to trigger “full-on” for emergency LED architectural fixtures on contact closure trigger. Provide unit with six opto-isolated DMX outputs.
2. Provide with restore switch.
   a. ETC DEBC-6
   b. Strand Equal

G. ELV Dimmer
1. Provide DMX-controlled, RDM-enabled, 600-watt single-circuit phase-adaptive dimmer for use with either magnetic or electronic dimming loads.
2. Coordinate with seating manufacturer.
3. Provide with surface-mount electrical enclosure.
   a. ETC UFD or UFD-MLV
   b. Strand Equal
   c. Lyntec Equal

H. 0-10V and Relay Panel
1. Provide surface-mount panel with DMX/RDM control, 8 relays and 8 0-10V dimming outputs.
2. Provide UL924 listed unit with normal power sense and emergency bypass capability.
3. Provide unit with independent 120V and emergency control.
4. Reference Electrical series drawings for emergency circuiting requirements.
5. Provide as required by control schedule.
   a. ETC Foundry UFMP8
   b. Strand Equal
   c. Lyntec Equal

2.12 LIGHTING CONTROL RACK

A. Provide wall-mount swing-out equipment rack to contain lighting control network equipment.

B. Size rack as required by system components plus 4 rack spaces unused and covered with blank panel for future expansion.

C. For Recital Hall only. Auditorium and Black Box lighting control equipment to be located in Audiovisual Equipment Racks.

D. Provide with locking front door, rack light and blank panels as required.
1. Middle Atlantic DWR Series
2. Lowell Mfg. L250 series
3. Raxxess Equal

2.13 DISTRIBUTION DEVICES

A. Provide control and switched power distribution devices as shown on the Drawings.
1. All devices shall be constructed of sheet metal. Provide all required mounting hardware.
2. All devices shall be provided with terminal strips for interconnection to the system wiring.

3. Outlet and Pigtail Boxes shall be fabricated from 18-gauge cold rolled steel with 16 gauge covers. They shall be finished with fine-textured, scratch-resistant, powder coat. Color per Architect.
4. Circuit numbers shall be ¾" labels with white letters on black background. Pigtails and outlets shall be spaced on as shown on the Drawings.
5. Provide hanger brackets for connector strips as required.
6. Label back boxes and faceplates with unique designations printed on removable adhesive labels to correspond to shop drawings.
7. Provide devices with finishes per schedule.
8. Provide Kellems style mesh strain relief per Drawings.

2.14 LED LIGHTING FIXTURES

A. General
1. Furnish all LED fixtures with installed edison connector on power cable, c-clamp, 10' DMX cable, and black safety cable.

B. LED Ellipsoidal Reflector Spotlight – Body
1. Provide color-changing LED ellipsoidal body suitable for interchangeable lenses, using 150 watts power (maximum) and with DMX in and through, power in and through and pattern holder. Provide unit with 20,000-hour LED life, and variable control profiles.
2. Provide fixtures that provides a minimum of 5,300 Lumens while producing 3000 Kelvin white light.
3. Provide each fixture with Rosco 119 diffusion gel installed in color frame.
   a. ETC ColorSource Spot
   b. Chauvet Ovation E-910FC
   c. Strand Equal
   d. Altman Equal
      1) Quantity: 72

C. 10 Degree Lens Tube
1. ETC410 LT
2. Equal
   a. Quantity: 4

D. 19 Degree Lens Tube
1. ETC 419 EDLT
2. Equal
   a. Quantity: 16

E. 26 Degree Lens Tube
1. ETC 426 EDLT
2. Equal
   a. Quantity: 24

F. 36 Degree Lens Tube
1. ETC 436 EDLT
2. Equal
   a. Quantity: 36

G. 50 Degree Lens Tube
1. ETC 450 EDLT
2. Equal
   a. Quantity: 12

H. LED Wash Light
1. Provide LED wash fixture with color mixing, DMX in and thru, power in and thru, hanging yoke. Provide with seven diffusion pattern set including round and oblong fields.

a. ETC ColorSource PAR Deep Blue
b. Chauvet Ovation P-56FC PAR
c. Equal
1) Quantity: 50

I. Cyclorama LED Light
1. Provide cyc light suitable for lighting 45 foot wide, 20-foot high cyclorama at 4-foot distance. Provide unit with any required diffusion to achieve smooth cyc coverage.
a. ETC ColorSource Cyc
b. Chauvet Ovation 1FC Cyc
c. Altman Spectra Cyc 200
d. Chroma-Q Equal
1) Quantity: 15

J. LED Worklight
1. Provide LED-based, tungsten-balanced, convection-cooled, 90+ CRI work light for use on electrics battens, and catwalks. Provide each unit with c-clamp, safety cable and installed Edison connector.
a. Altman LED Worklight
b. Osram Kreios FLx 90W
c. Equal
1) Quantity: 12

K. Follow Spot
1. Provide 600-watt, cool-white LED follow-spot appropriate for 90-foot throw with approximately 7 degree to 13 degree zoom and 50,000 light source life. Provide unit with iris, mechanical douser, and boomerang color changer. Provide with 25-foot power cable. Provide with DMX input and output, adjustable yoke and floor stand.
a. Robert Juliat Oz
b. Canto Astro 600
c. Lycian Equal
d. Equal
1) Quantity: 2

2.15 SHARED ACCESSORIES

A. Side Arms, 24”
1. Provide 24-inch side arms with two sliding tees for use on “box boom” positions.
2. Provide side arm with clamp and secondary support brace, designed to attach to vertical pipe. C-clamp attachment is not acceptable.
3. Provide:
a. City Theatrical #204
b. Equal
1) Quantity: 10

B. Top Hat, Small
1. Provide full top-hat for 6.25-inch fixture.
a. ETC
b. City Theatrical
c. Altman
1) Quantity: 36

C. Iris
1. Provide iris compatible with ETC Source4 ellipsoidal reflector spotlights.
a. City Theatrical
b. ETC

c. Altman
1) Quantity: 6

D. Scenery Bumper
1. Provide 18-inch scenery bumper with pipe clamp.
a. City Theatrical #1340
b. SSRC Equal
c. Altman Equal
1) Quantity: 6

E. Template Holders
1. A-size Template Holder for ERS fixture.
a. City Theatrical
b. ETC
c. Altman
1) Quantity: 30

F. Black Safety Cable (spare)
1. ETC
2. SSRC
3. City Theatrical
a. Quantity: 30

G. Extension Cables
1. Provide 12/3 SO edison extension cables with color-coded length marker and knotted tie line in length as quantities below
a. 5 foot: 10
b. 10 foot: 10
c. 25 foot: 8
d. 50 foot: 4
2. Provide molded edison two-fer.
a. Quantity: 12
3. Provide hard-service DMX extension cables with color-coded length marker and knotted tie-line in lengths and quantities below:
a. 5 foot: 28
b. 10 foot: 15
c. 25 foot: 15
d. 50 foot: 5
e. 100 foot: 2
4. Ethercon Ethernet Extension Cables
a. Provide black heavy-duty Cat5e extension cable with Neutrik Ethercon connectors and quantities below.
b. Acceptable Products
1) Lex Products CAT5-EC
2) Equal
a) 10 foot: 8
b) 25 foot: 8
c) 50 foot: 4
d) 100 foot: 2
5. Provide power “thru” cable with PowerCon male to Powercon Female, or as appropriate for fixtures.
a. 10 foot: 60
b. 25 foot: 50
c. 50 foot: 20

H. DMX/RDM Splitter, Portable

1. Provide one-input DMX/RDM splitter with six optically isolated outputs. Provide with bracket for pipe mounting.
    a. Elation RDMX6S
    b. Doug Fleenor Equal
    c. ETC Equal
        1) Quantity: 2

I. DMX Tool
1. Provide DMX test tool for use with Android, iPhone or Amazon Fire devices.
    a. City Theatrical DMXCAT
    b. Equal
        1) Quantity: 1

J. Lens Storage Bin
1. Provide plastic bin with securable cover to store all diffusion elements associated with theatrical lighting fixtures.

K. Storage Hamper
1. Provide sixteen-bushel canvas storage hamper with steel frame, heavy-duty castors and hinged plywood top for storage of spare instruments and cable.
    a. Steele Canvas Model 82
    b. Global Industrial Equal
    c. Royal Basket Equal
        1) Quantity: 4

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine areas where performance dimming and control equipment is to be installed and verify that conditions are satisfactory for installation, complying with both the Manufacturer's requirement and this specification.

3.2 INSTALLATION

A. Coordinate installation of system with Electrical Trade Contractor.

B. Terminate all low-voltage connections.

C. Load circuit conductors shall be continuous from the panel board to the back box. Do not splice conductors.

D. Coordinate control with Audiovisual System Contractor:
1. Create presets within control processor for recall by audiovisual control system.
2. Coordinate IP addressing scheme if direct Ethernet connection is made from audiovisual control system to lighting system.

E. Lighting fixtures:
1. Deliver lighting fixtures to designated area
2. Unpack all fixtures, remove packing materials
3. Hang, circuit, channel, focus and configure repertory light plot in Auditorium and Black Box Theater.

F. Architectural Control
1. Program presets in consultation with Owner and Consultant.

G. Architectural Lighting Fixtures
   1. Perform all DMX terminations on DMX-controlled LED drivers in Auditorium and Black Box Theater.
   2. Coordinate and integrate DMX addressing scheme with Electrical Trade Contractor.
   3. Test DMX addressing and RDM functionality of LED drivers.
   4. Address all lighting fixtures.

3.3 TOUCH PANEL THEORY OF OPERATION

A. Modes
   1. Default/Work
      a. Console or panel control of house and stage lighting.
      b. All stations active.
   2. Show
      a. Console or panel control of house lighting.
      b. Establish lower limit on house and aisle light dimming to ensure code-required level of illumination at all times.
      c. Lockout of entry stations. Reset entry stations to active at 11:00 PM each night.
   3. Night
      a. Allow all lights to be turned off.
      b. Create scene to preserve 1 foot-candle of illumination for safety.

B. Breaker Panel Control
   1. Page for control of circuit breakers in groups:
      a. Distribution devices w/ timer cycle for automated on/off of breakers
      b. House lights – manual control only
      c. Convenience outlets – manual control only

C. House Light Control
   1. Presets:
      a. House Full
      b. Presentation
      c. House 75%
      d. House 50%
      e. House 25%
      f. House Out
   2. Faders
      a. Individual faders for each zone of house light control
   3. Color Control
      a. Graphical color picker for color-changing fixtures.

D. Auditorium Stage Lighting Control
   1. Fader control of three “specials” for use with video presentations
   2. Fader control of acoustic ceiling panel fixtures.

E. Black Box Theater
   1. Individual and group control of house lights.

F. Entry Panels
   1. Cleaning – Full On
   2. Off

G. Recall of 16 presets.
   1. User shall be able to change name of presets.
   2. User shall be able to change content of preset via scene capture.

3.4 FIELD QUALITY CONTROL

A. Post-Completion Inspection Report
   1. Test all dimmed and switched power outlets for correct electrical termination and for correct control.
   2. Confirm that all architectural lighting fixtures that are controlled by the theatrical dimming system are operational and lamped.

B. Manufacturers' Field Services
   1. Provide the services of a Manufacture-certified field service technician to verify the installation and operation of the control system.

3.5 SYSTEM CHECKOUT

A. After receipt of the Post-Completion Inspection Report, the Architect will schedule an inspection and operational test of the system.

B. Make all loose equipment specified for the lighting system available at time of checkout.

C. Provide full and uninterrupted access to stage, auditorium and technical areas required for commissioning tests. Occasional blackouts of the lighting will be required during this checkout.

D. A Lighting System Contractor's project representative shall be present during tests.

E. Provide a Manufacturer's certified field service technician shall be present during all tests and inspections and available for system programming.

F. Provide personnel to operate equipment and perform adjustments as necessary.

G. Provide access to equipment as required.

3.6 DEMONSTRATION AND TRAINING

A. Provide 16 hours of training in four separate sessions, by factory-authorized personnel, for end-users in the operation of the system.

END OF SECTION

Section 26 51 00

INTERIOR LIGHTING

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. Section Includes:

1. Interior Lighting fixtures
2. LED Luminaires and Light Sources
3. Emergency Lighting
4. Exit Signs
5. Lamps
6. Drivers
7. Miscellaneous

1.4 DESCRIPTION OF WORK

A. Description of Work: Provide and install all lighting fixtures, complete with lamps, drivers, wiring, and control.

1. All materials, accessories, and any other equipment necessary for the complete and proper installation of all lighting fixtures included in this Contract shall be furnished by the Contractor, including those not usually indicated on the drawings or specified, but that are necessary for the proper installation and operation of the fixtures.
2. Specifications and drawings are intended to convey the salient features, function, and character of the fixtures only, and do not necessarily illustrate or set forth every item or detail necessary for completion of the work.
3. Verify final ceiling type with final architectural reflected ceiling plans prior to ordering fixture. Provide mounting accessories for proper installation in ceiling type.

4. Minor details not usually indicated on the drawings nor specified, but that are necessary for the proper execution and completion of the fixtures, shall be included, the same as if they were herein specified or indicated on the Drawings.
5. Conformance: Fixtures shall be manufactured and installed in strict accordance with the Contract Documents. The Contractor shall be held responsible for the omission or absence of any detail, construction feature, etc. which may be required in the manufacture and installation of the fixtures. The responsibility of accurately fabricating and installing the fixtures to the fulfillment of this specification rests with the Contractor.
6. Support: Fixtures shall be securely attached to support system to meet all code requirements.
7. Codes: Materials and installation shall be in accordance with the applicable edition of the National Electrical Code (NKC) and any applicable Federal, State, and local codes and regulations.
8. UL Listing: All fixtures shall be manufactured in strict accordance with the appropriate and current requirements of the Underwriters Laboratories, Inc. "Standards for Safety," and others as they may be applicable. A UL listing shall be provided for each fixture type, and the appropriate label or labels shall be affixed to each fixture or components in a position concealing it from normal view.

B. Definitions:

1. CCT: Correlated color temperature
2. CRI: Color-rendering index
3. LER: Luminaire efficacy rating
4. Lumen: Measured output of lamp and luminaire, or both.
5. Luminaire: Complete lighting fixture, including remote driver housing (if required)
6. SDCM: Standard Deviation of Color Matching

1.5 REFERENCES

A. Comply with the latest edition of the following applicable specifications and standards except as otherwise shown or specified:

1. ANSI/ASHRAE/IES - Standard 90.1
2. ANSI C78.377 - Chromaticity
3. ANSI C62.41 - Recommended Practice for Surge Voltages in Low-Voltage AC Power Circuits
4. CIE TC1-69 - Color Rendering
5. IESNA LM-79 - Approved Method for Electrical & Photometric Measurement of SSL Products
6. IESNA LM 80 - Approved Method for Lumen Maintenance of LED Light Source
7. IESNA RP1605 - Nomenclature and Definitions for Illuminating Engineering
8. NEMA LE 4 - Ceiling Compatibility for Recessed Fixtures
9. NFPA 70 -National Electrical Code (NEC)
10. NFPA 101-Life Safety Code
11. UL 57 - Electric Lighting Fixtures
12. UL 924 - Emergency Lighting and Power Equipment
13. UL 1598 - Luminaires
14. UL 8750 - LED Equipment for Use in Lighting Products

1.6 SUBMITTALS

A. Submit the following items:

1. Data/catalog cuts for each product and component specified herein, listing all physical and electrical characteristics and ratings indicating compliance with all listed standards.
   a. Clearly mark on each data sheet the specific item(s) being submitted and the proposed application.
   b. Reference catalog cuts to the applicable specification article.

2. Photometric layouts are required prior to the approval of the product data. Provide point-by-point calculations for the entire building. Calculations showing typical areas shall not be acceptable.
   a. Provide photometric layout using industry approved lighting software.

3. For standard catalog items with no modifications, submit cut sheets that clearly show all elements lo be supplied, and all corresponding product data. If a cut sheet shows more than one (1) fixture type, all non-applicable information shall be crossed out. Submittals must be prepared by the manufacturer or manufacturer's local representative agency and include a cover sheet for each fixture type which clearly indicates the following:
   a. Lighting fixture physical description, type, size including all dimensions, material, indoor/outdoor, diffusers/lenses, baffles, finishes, and means and methods of attachment.
   b. Manufacturer and model of fixtures (inclusive of drivers, dimming modules, power supplies, lamps, etc.).
   c. Lighting fixture performance including system wattage, system lumen output, light quality including color temperature and color rendering index .
   d. Project name.
   e. Name of manufacturer's representative agency.
   f. Complete catalog number for the lighting fixture including accessories and options and any miscellaneous items detailed in the written description of the specification.
   g. Where applicable, LED driver information including manufacturer, characteristics, type, model number and voltage. Provide manufacturer's test report for electronic drivers and test data for drivers regarding the tripping class P units based on the specified criteria.

4. For some lighting fixtures, annotated catalog cuts will not be sufficient, and detailed factory shop drawings will be required. For linear lighting systems, provide factory shop drawings showing all run lengths and patterns, with reference to location in the project by drawing number or room number. For architecturally integrated lighting fixtures, verify field dimensions and include them on shop drawings showing exact locations of fixtures.
5. Where applicable, shop drawings shall include wiring diagrams, scale plans, and details showing the method of installation of LEDs and LED boards, reflectors, track, suspension hardware, transformers, drivers, and secondary feeds, as well as a complete bill of materials.
6. All changes to shop drawings are to be "clouded" and dated prior to resubmission. No variation from the general arrangement and details indicated in the Contract Documents shall be made on the shop drawings, unless required to suit the actual conditions on the premises, and then only with the written acceptance of the Architect and Lighting Designer. All variations must be clearly marked as such on drawings submitted for approval.
7. Provide alphabetized index of all submitted items, listing manufacturer, catalog #, LED or lamp manufacturer, and LED or lamp catalog number.

8. Photometric test report for each luminaire type and lamp combination listed on the Fixture Schedule/Catalog cuts. Test reports shall be based on Illuminating Engineering Society published test procedures and shall contain candlepower distribution curves in five lateral planes for fixtures with asymmetric distributions and fixture luminance data for vertical angles above 45 degrees from nadir.
9. Shop drawings:
    a. Suspension details for all fixtures recessed in, mounted on, or suspended from hung ceilings. Details shall clearly illustrate proposed fixing methods for fixtures requiring support independent of the suspended ceiling system.

10. Review of shop drawings or samples does not waive contract requirements. Approval of the shop drawings or samples does not relieve the Contractor from responsibility for deviations from the specifications or drawings, unless he has provided a letter noting such deviations at time of submission, and received written approval for such deviations from the Architect and Lighting Designer.
11. Approval of shop drawings or samples does not relieve the Contractor from responsibility for errors in the shop drawings or samples. Contractor shall be fully responsible for lighting fixtures that are manufactured or installed without approved shop drawings, and for fixtures not manufactured in accordance with the requirements of the Architect's and Lighting Designer's shop drawing reviews.
12. If requested by the Lighting Designer or Architect, submit samples of any fixture type for approval prior to manufacture.
    a. The samples shall be complete with specified LEDs or lamps and driver ready for hanging, energizing, and examining, and shall be shipped to the Lighting Designer, or as otherwise advised.
    b. Samples must be actual working units of fixtures to be supplied. For linear lighting fixtures, specified by the foot, provide a minimum length of four feet.
    c. Samples will be returned but shall not be included in quantities listed for a project.
    d. All costs to provide samples, including all shipping, shall be borne by the Contractor.

13. The Contractor shall identify any long lead times or lighting fixture delivery issues that may adversely affect the project schedule, and immediately bring them to the attention of the Owner's Representative.
14. Unit Cost Data: For each type of lighting fixture included in the fixture schedule, submit separate unit costs for materials and for labor for all components of a specified luminaire.
15. Qualification Data: For qualified agencies providing photometric data for lighting fixtures.
16. Submit manufacturer's installation instructions.
17. Complete bill of material listing all lighting fixtures and components.
18. Warranties.

B. Operation and Maintenance manuals submittals shall include the following:

1. A detailed description and catalog cut of each lighting fixture type.
2. Instructions for routine maintenance and tools required.
3. Pictorial parts list and part numbers.
4. Types of cleaners to be used.
5. Final, as-built shop drawings.
6. Telephone numbers for the authorized parts and service distributors.
7. Warranties.

1.7 SUBSTITUTIONS

A. The light fixture package specified on the drawings has been certified by a third party employed by the Owner/Utility Company for the purpose of computing utility company rebates to the owner.

1. The Electrical Contractor will employ and pay for the services of the third party designated by the Utility Company to evaluate the substituted fixture package and to compute utility company rebates to the owner.
2. The Utility Company rebates to the Owner shall be equal to or greater than the specified fixture package.
3. Once the substituted package is certified it shall be submitted to the Engineer for approval.
    a. Provide point-by-point lighting calculations of the entire building and site.
    b. Provide Total Light Power Density (LPD) per floor and for the whole building.
    c. The LPD of the substituted luminaires shall be less than or equal to the specified luminaires.
4. Provide a side-by-side comparison between the specified and the substituted fixtures include the following criteria:
    a. Input Watts
    b. Voltage
    c. Output Lumens
    d. Energy Star Rating
    e. DLC approval
    f. Total Light Power Density (LPD) per floor and for the whole building.

1.8 DRAWINGS

A. The drawings, which constitute a part of these specifications, indicate the general location of the luminaires.

B. Specifications and drawings are for assistance and guidance, but exact locations, distances and levels will be governed by actual field conditions. Contractor is directed to make field surveys as part of his work prior to submitting system layout drawings.

1.9 QUALITY ASSURANCE

A. All materials, equipment and parts comprising the units specified herein shall be new.

B. Materials, equipment and appurtenances as well as workmanship provided under this Section shall conform to the highest commercial standard as specified.

C. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910, complying with the IESNA Lighting Measurements Testing and Calculation Guides. Alternatively, photometric testing data can be provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

E. Comply with NFPA 70.

F. FM Global Compliance: Lighting fixtures for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.

G. Materials, equipment, and accessories as well as workmanship provided under this section shall conform to the highest commercial standards and as specified and as indicated on drawings. Luminaire parts and components not specifically identified or indicated shall be made of materials most appropriate to their use or function and as such resistant to corrosion and thermal and mechanical stresses encountered in the normal application and function of the luminaires.

H. All luminaires shall be manufactured to a consistent level of quality. Size, color and components parts shall be identical for all Luminaires.

I. All new luminaires and related materials shall be new.

J. The Contractor shall coordinate all luminaires, mounting hardware, and trim with ceiling system and other items, including work of other trades.

K. Mockups; Will be specified prior to fixtures procurement.

1. Obtain Architect's approval of fixtures for mockups before starting installations.
2. Provide interior lighting fixtures for mock-ups, complete with power and control connections.
3. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work unless the Architect or Lighting Consultant stipulates otherwise.

1.10 WARRANTY

A. Comply with Section 260001.

B. The Electrical Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

C. Luminaires shall be provided with a 5-year warranty covering, LEDs, drivers and paint finish.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers, products represented by the following rep firms:

1. Reflex Lighting.
2. Apex Lighting.
3. Boston Light Source.

4. Omnilite | Illuminate.
5. Or approved equal.

B. Basis of Design products shall be by Reflex Lighting.

2.2 LIGHT FIXTURES

A. Provide and wire lighting fixtures scheduled or indicated by type designation on the drawings. If type designation is omitted, fixtures shall be of the same type as shown for rooms of similar usage. Verify before purchase and installation. No alternative fixtures will be accepted.

B. Locations of fixtures on electrical drawings are diagrammatic. Verify location and spacing with architectural reflected ceiling plans and other reference data before purchasing. Coordinate space conditions, including headroom clearances and interferences with ceiling components such as ducts, openings, beams and piping prior to installation. Allow for movement of up to 9 feet from indicative location on plans.

C. Check the architectural finishes and, regardless of the catalog prefixes and suffixes shown, furnish fixtures with the proper trim, frames, supports, hangers and other miscellaneous appurtenances or properly coordinate with said finishes. Where required, furnish reinforcing for ceiling construction to support the weight of the fixtures.

D. Fixtures shall be free of light leaks and designed to provide sufficient ventilation of LEDs and drivers, including vent holes where required. Outdoor fixtures with vent holes shall have wire mesh screens in the vent holes.

E. Light shields and lens shall be as specified under individual fixture types.

F. Replace blemished, damaged, or unsatisfactory fixtures at no additional cost and in a manner satisfactory to the Owner's Representative.

G. Reflector cones, baffles and decorative elements of fixtures shall not be installed until completion of plastering, ceiling tile work, hanging and general cleanup in the area unless fully protected from dust ingress.

H. Provide labor and materials for final targeting of adjustable fixtures under supervision of the Owner's Representative Targeting shall take place immediately before building is turned over to the Owner and after regular working hours where required.

I. In fixtures with asymmetrical beams, adjustment devices shall be set to ensure permanent orientation of light beam and shall not be affected by servicing LEDs, lamps, or drivers.

J. Surface and stem mounted fixtures: Provide auxiliary supports for mounting fixtures in areas without suspended ceilings. Luminaires shall be independently supported with dedicated fixings (unless it is agreed otherwise) from the soffit. Do not mount fixtures to piping, ducts or other mechanical equipment.

K. Complete units and all electrical components for light fixtures shall bear the UL label. Labels shall not be placed on fixtures at locations where installation of unit labels is visible.

L. Reflectors, cones or baffles shall be free of spinning lines, ripples or any marks or indentations caused by riveting or other assembly techniques. No rivets, springs or other hardware shall be visible after installation.

M. All exposed metal parts of exterior lighting fixtures shall be stainless steel, anodized aluminum or have 4 mil zinc coating applied after fabrication and before finish. Screws and fastening shall be stainless steel. Painted finishes shall be as specified in schedules.

N. If ceiling system requires, each recessed and semi-recessed fixture shall be furnished with a mounting frame or ring compatible with the ceiling in which they are to be installed. The frames and rings shall be one-piece or constructed with electrically welded butt joints, and of sufficient size and strength to sustain the weight of the fixture. Yokes, brackets and supplementary supporting members, needed to mount lighting fixtures to carrier channels or other suitable ceiling members, shall be furnished and installed by the Contractor. There should be no light leaks between ceiling trims of recessed lighting equipment and ceilings, or when fixtures arc installed in partially transparent ceilings. Verify the ceiling type and suspension method prior to ordering fixtures. The Architect's favorable review of shop drawings for both the ceiling system and the lighting fixtures will not relieve the Contractor of the ceiling/lighting fixture compatibility requirement.

O. Plastic for lenses and diffusers shall be formed of colorless 100% virgin acrylic, as manufactured by Rohm & Haas, DuPont. or equally acceptable manufacturers. The quality of the raw material must meet American Society of Testing Materials (ASTM) standards, as tested by an independent testing laboratory. Acrylic plastic lenses and diffusers shall be properly cast, molded, or extruded, as specified, and shall remain free of any dimensional instability, discoloration, embrittlement, or loss of light transmittance for at least 15 years. Glass used for lenses, refractors, and diffusers shall be crystal clear in quality with a transmittance of no less than 88%. Exterior fixtures shall use tempered Borosilicate glass, Corning #7740 or equal. For fixtures directly exposed to the elements and aimed above the horizontal, use Corning Vycor glass or equal. Where optical lenses are used, they shall be free from spherical and chromatic aberrations and other imperfections that may hinder their functional performance.

2.3 LED LUMINAIRES AND LIGHT SOURCES

A. Only LED boards and modules supplied by [he original fixture manufacturer shall be offered for submittal.

B. For all LFO products specified the Contractor shall submit the fixture specified with the current LED technology available within the specified fixture range at the time of submittal, ensuring that the required lumen output is achieved. If the specified fixture has been updated the revised fixture shall achieve a minimum light output ratio equal to the luminaire specified.

1. Color Tolerance: Unless otherwise specified, all LED light sources shall achieve a minimum color tolerance of at least 3-stcp ellipse, measured for both initial and at 25% of rated life. Color tolerance beyond this is unacceptable.
2. Color Rendering Index: Color rendering index (CRI) of all LED light sources shall achieve the minimum CRI specified initially and at 25% of rated life. No variation in CRI between initial and 25% rated life is acceptable.
3. Life Expectancy: Lifetime testing of LED light sources shall be carried out in accordance with LM-80-08. All LED light sources shall achieve a minimum performance of L70, where rated life of the LED light source is defined as the time taken to reach 70% of the initial lumen output.
4. All LED light sources shall achieve a minimum lifetime of 50,000 hours at L70.
5. All LED light sources shall not exceed a failure fraction of 10% (F10) at rated life (L70).
6. Lumen Depreciation: Unless otherwise specified, all LED light sources shall provide a maximum lumen depreciation of 30% over the rated life of the product.
7. Power Factor: LED drivers shall achieve a minimum power factor of 0.9.

8. LED system shall use 16-bit or greater nonlinear scaling techniques for high-resolution output.
9. Visible blinking, flickering or strobing shall not be acceptable at full lumen output, nor at any dimming level should dimming be specified.
10. Audible noise when at full lumen output or at any dimming level shall not be acceptable.
11. The Contractor shall ensure the LED driver is fully compatible with the proposed lighting control system as to ensure correct smooth operation of LED output at all dimming outputs without flicker, strobing, or other noticeable effect on lighting performance.

C. Luminaire Testing: The following tests shall be undertaken for all LED products specified, including those identified as custom products. Confirmation that these tests have been carried out and passed is required during submittal.

1. Temperature cycling shock test: The non-energized LED luminaire shall be stored firstly at -20°C for 1 hour. The luminaire shall then be immediately moved into a cabinet having a temperature of+35°C and stored for 1 hour. Five such cycles shall be carried out. At the end of the test the LED luminaire shall operate and remain alight for 15 min.
2. Supply voltage switching test: At test voltage the luminaire shall be switched on and off for 30 seconds. The cycling shall be repeated for a number equal to half the rated luminaire life in hours (example: 10K cycles if rated luminaire life is 20 000 hours). At the end of the test the LED luminaire shall operate and remain alight for 15 min.
3. Thermal endurance test. The LED luminaire shall be operated at nominal voltage and at an ambient temperature of (plus) +35°C for outdoor luminaires, (plus) +25°C for indoor luminaires and (plus) +35°C for recessed luminaires until a test period equal to 25 % of the rated luminaire life (with a maximum of 6 000 hours) has passed. At the end of this time, and after cooling down to room temperature, the luminaire shall remain alight for at least 15 min.

D. LED Light Source and Luminaire Data: The following data for LED light sources shall be submitted for approval with all luminaires equipped with LED light sources:

1. Initial Luminaire Lumen Output at 1,000 hours (LI000).
2. Ral4 color rendering data, in addition to the general color rendering index Ra. Provide initial and data at 25% of rated life.
3. Color tolerance data, initial and at 25% of rated life, including the chromaticity coordinates of the bin.
4. Rated power of the luminaire including driver.
5. Power factor of the luminaire including driver, initial and at 25% of rated life.
6. Absolute photometry report in accordance with LM-79-08.
7. LED light source lest reports in accordance with LM-80-08.

E. WHITE LED UNITS

1. Usable life shall be 50,000 hours minimum, defined by the point in which the lamp output has decreased by 30% from its initial output.
2. Base CCT shall be per specification. All LEDs supplied must be within a tolerance of+/- 100K from base color temperature. Additionally, all LEDs shall be sourced from the same bin.
3. Chromaticity Tolerance shall be no more than 0.03 on the CIE chromaticity diagram from the black body curve.
4. Lamp CRI shall be a minimum of 80, unless otherwise specified.

2.4 LED EXIT LIGHT FIXTURES

A. Description; Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction, dual circuit.

B. Internally Lighted Signs: Lamps for AC Operation: LEDs, 70.000 hours minimum rated lamp life.

C. Exit light fixtures shall meet applicable requirements of NFPA and UL.

D. Exit signs for both wall and ceiling mount applications shall be installed recessed with 90-minute backup battery power. Surface mount exit signs shall not be acceptable.

E. Face color shall be Green; Housing color shall be coordinated with the Architect prior to ordering.

F. There shall be no radioactive material used in the fixtures.

G. Directional Arrows: Provide directional arrows as part of the inscription panel where required or as shown on drawings. Directional arrows shall be the "chevron-type" of similar size and width as the letters and meet the requirements of NFPA 101.

2.5 DRIVERS

A. LED Drivers and Dimming Controllers

1. Acceptable means of dimming unless otherwise noted in Fixture Schedule:
   a. Pulse Width Modulation and hybrid Pulse Width Modulation with Constant Current.
   b. All drivers shall comply with IEC Standard 62386, Parts 101 & 102.

2. Dimming: continuously from 100% to 1% unless otherwise noted in the fixture schedule and the specified performance requirements.
3. Driver shall start LED at any dimming position.
4. Life:
   a. 70,000 hours lifetime, minimum.
   b. Driver failure rale per 1000 hours operating at 60 degrees Celsius ambient, shall be 0.2 percent or less.

5. Input: 120-277 V, 50-60 Hz.
6. Supply: 24VDC constant current (unless otherwise specified).
7. Operation:
   a. Driver shall automatically shut down in case of LED failure condition.
   b. Driver shall be provided with miss-wire protection circuitry.
   c. Driver shall be provided with short circuit and open circuit protection circuitry.
   d. Driver shall contain automatic restart circuitry in order to restart LEDs after LED replacement.
   e. Driver Power Factor at full light output shall be greater than 0.98.
   f. Driver Power Factor across dimming range shall be greater than 0.90.

B. Control

1. Refer to the fixture schedule and lighting control specification for full driver control requirements.

a. Provide fixtures with correct drivers as specified within the fixture schedule and coordinate with the lighting control system to ensure compatibility.
b. Standard dimming protocol for static white light to use 0-10v control signal.
c. Standard dimming protocol for tunable white to use DALI control signal.
d. Standard dimming protocol for color changing RGB light to use DMX control signal.

2.6 MISCELLANEOUS

A. General LED Requirements:

1. Life: Rated Lumen Maintenance Life (per LM-80-08) shall be minimum 50,000 hours at L70 with Forward Phase Control
2. Maintenance
   a. Provide plug-n-play connectors (e.g. Molex, Wago) in lieu of soldered connections so that LED boards can be removed and replaced with minimal tools in the event of a failure.
   b. All LED boards and drivers shall be accessible for maintenance without the use of special tools.

3. Protection
   a. Protective circuitry - Power/data supply outputs shall have current limiting protection. Power/data supply shall provide mis-wiring protection.
   b. All hardwired connections to LED fixtures shall be reverse polarity protected and provide high voltage protection in the event connections arc reversed or shorted during the installation process.
   c. Power/data supply shall have power factor correction.

B. Disconnect Means

1. Provide disconnecting means for the following fixture types:
   a. Light fixtures with multiple drivers and multi-wire circuits.
   b. Occupancy sensor-controlled lighting without multiple override switches.
   c. Remote lighting control without overrides within sight of the lighting.

2. Disconnect means is required internal or external to the fixture, for each fixture and in sight of the fixture. Acceptable means include a switch integral to the luminaire or a quick-disconnect between driver and branch circuit wiring connection internal to the luminaire.
3. Complete wiring disconnection including the ground wire is required for multi-wire circuits to fixtures.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Luminaires are shown diagrammatical on drawings. Coordinate luminaire installation with other trade drawings and reflected ceiling drawings. Provide luminaires. supports and accessories needed to meet space or ceiling arrangement constraints.

B. Prior to ordering suspended or surface mounted continuous row luminaires for walls, coves, soffits, valances, or cabinets, verify overall lengths with the Architectural drawing layouts and details or specialty craft shop drawings.

C. Recessed Downlights: Review Architectural drawings for insulation details and provide luminaires suitable for use in direct contact with insulation where required.

3.2 INSTALLATION

A. Installation shall be in accordance with the NEC, manufacturer's instructions, and as shown on the drawings or specified.

B. Lighting fixtures: Set level, plumb, and square with ceilings and walls.

C. Install suspended exit signs using stem pendants from swivel hangers.

D. Install suspended luminaries using stem pendants from swivel hangers, aircraft cable, and chain in accordance with the intended design. Provide stem pendants, aircraft cable, and chain lengths required to suspend luminaires at indicated height.

E. Wall-mounted fixtures shall be attached to the studs in the walls, or to a 20-gauge metal backing plate that is attached to the studs in the walls. Lighting fixtures shall not be attached directly to gypsum board.

F. Lighting Fixture Supports:

1. Shall provide support for all of the fixtures. Supports may be anchored to channels of the ceiling construction, to the structural slab or to structural members within a partition, or above a suspended ceiling.
2. Shall maintain the fixture positions after cleaning and re-lamping.
3. Shall support the lighting fixtures without causing the ceiling or partition to deflect.
4. Hardware for troffers:
   a. Hardware devices shall independently support the fixture from the building structure at two opposite points.
5. Stem hung fixtures shall be provided with ball swivels, located at the canopies, and rockers, at the fixtures, allowing a minimum 45-degree swing from the vertical. Stems shall be of 3/8-inch ID minimum pipe and shall be finished to match the lighting fixture.
6. For fixtures mounted in continuous rows where individual fixtures are mounted on common mounting channels, or otherwise rigidly fastened together, install one support (stem, AC cable or chain) for each 4-foot lamp length and 2 for each 8-foot lamp length.

G. Backing for surface mounted or stem hung linear fixtures shall be structural channel or angle iron with 5/16" bolts, except where mounted directly to concrete structures, in which case anchors and suspension shall be used. The exact method of support shall be determined in conjunction with the Owner's Representative.

H. All light fixtures installed in gypsum board ceilings or plaster soffits shall be provided with metal frames. Fixtures in concrete shall be steel housing with bitumastic paint finish and approved for use in concrete. Fixtures shall be compatible with type of ceiling.

I. Light fixtures which are to be mounted in continuous rows of two or more fixtures shall have at least two bolts or other interlocking devices, as approved by the Architect, at each connection to provide for positive and true alignment of the fixtures.

J. All light fixtures contained within architectural details (i.e., cove, slots, valances, etc.) shall be continuous with fixtures tightly butted up against each other to reduce shadows. Actual illuminated length shall be centered in overall detail with equal spacing at each end. All concealed lighting of this nature shall be closely coordinated with architectural details where indicated in lighting fixture schedules.

K. Recessed light fixtures shall be independently supported by #10 AWG wires to specified anchors in the slab above.

L. Provide all lighting fixtures recessed in a ceiling which has a fire-resistant rating of one hour or more with box enclosures which have a fire rating equal to that of the ceiling. The space from the fixture to the enclosure shall be 3" for fixtures with 120V screw base sockets and 1" for other light fixtures.

M. Verify weights and recommended mounting methods of all decorative fixtures with manufacturers and furnish and install supports. Fixtures weighing more than 10 pounds shall be supported independently of the outlet box.

N. Luminous ceiling and wall cavities shall be completely enclosed with gypsum board and shall be painted with 90% reflecting white paint. Cavities shall be free of all obstructions including piping and ductwork, except for branch circuit wiring to fixtures in luminous ceiling. Branch circuit wiring in luminous ceiling shall not extend to fixtures outside luminous ceiling. The installation of luminous ceiling diffusers shall be in accordance with drawing details and as described in these specifications.

O. Locale recessed ceiling luminaires as indicated on the Architect's reflected ceiling plan.

P. Install wall mounted luminaires and exit signs at height as indicated on Architectural Drawings.

Q. Install surface mounted luminaires and exit signs plumb and adjust to align with building lines and with each other. Secure to prohibit movement.

R. Lighting fixtures in mechanical spaces and machine rooms are shown in their approximate locations only. Do not install light outlets or fixtures until mechanical piping and ductwork are installed; then lighting fixtures shall be installed in locations best suited for equipment arrangement and as approved by the Architect. Verify locations of fixtures in elevator machine rooms before installation.

S. Exterior fixtures requiring exposed exterior boxes shall be mounted on east boxes equipped with gaskets.

T. Replace luminaires that have failed LEDs, lamps, drivers at Substantial Completion.

U. Louvers, diffusers or lenses shall not be installed in lighting fixtures until such time as all glazing has been completed and all construction work involving plastering, grinding, sanding, painting, etc., and final clean-up sweeping and dusting have been completed.

V. Clean all lamps, lenses, and optical chambers after installation.

W. After the installation is completed, remove, and replace any driver which is judged by the Owner's Representative to be excessively noisy.

X. Clean up and repair any damage to the finished building caused by installation of the light fixtures.

Y. The electrical contractor and ceiling trades shall coordinate to ascertain that approved lighting fixtures are furnished in the proper sizes and installed with the proper devices (hangers, clips, trim frames, flanges, etc.), to match the ceiling system being installed.

Z. Bond lighting fixtures to the grounding system as specified in Division 26.

AA. At completion of project, replace all defective components of the lighting fixtures at no cost to the Owner.

3.3 ACCEPTANCE CHECKS AND TESTS

A. Perform the following:

1. Visual Inspection:
   a. Verify proper operation by operating the lighting controls.
   b. Visually inspect for damage to fixtures, lenses, reflectors, diffusers, and louvers. Clean fixtures, lenses, reflectors, diffusers, and louvers that have accumulated dust, dirt, or fingerprints during construction.

2. Electrical tests:
   a. Exercise dimming components of the lighting fixtures over full range of dimming capability by operating the control devices(s) in the presence of the Engineer/Commissioning Agent. Observe for visually detectable flicker over full dimming range and replace defective components at no cost to the Owner.
   b. Burn-in all lamps that require specific aging period to operate properly, prior to occupancy by the Owner. Burn-in period to be 40 hours minimum, unless specifically recommended otherwise by the lamp manufacturer. Burn-in dimmed fluorescent and compact fluorescent lamps for at least 100 hours at full voltage, unless specifically recommended otherwise by the lamp manufacturer.
   c. Replace any lamps and ballasts which fail during burn-in.

3.4 FOLLOW-UP VERIFICATION

A. Upon completion of acceptance checks and tests, the Electrical Subcontractor shall show by demonstration in service that the lighting systems are in good operating condition and properly performing the intended function.

3.5 TRAINING AND SERVICE

A. Comply with Section 260001.

B. Conduct two 4-hour training sessions. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

End of Section

Section 26 56 00

EXTERIOR LIGHTING

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. Section Includes:

1. Exterior luminaires with lamps and ballasts.
2. Poles and accessories.
3. See Division 26 Section "Interior Lighting" for exterior luminaires normally mounted on exterior surfaces of buildings.

1.4 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color-rendering index.

C. HID: High-intensity discharge.

D. LER: Luminaire efficacy rating.

E. Lumen: Measured output of lamp and luminaire, or both.

F. Luminaire: Complete lighting fixture, including ballast housing if provided.

G. Pole: Luminaire support structure, including tower used for large area illumination

H. Standard: Same definition as "Pole" above.

1.5 STRUCTURAL ANALYSIS CRITERIA FOR POLE SELECTION

A. Dead Load: Weight of luminaire and its horizontal and vertical supports and supporting structure, applied as stated in AASHTO LTS-4.

B. Live Load: Single load of 500 lbf (2224 N), distributed as stated in AASIITO LTS-4-M..2.3.

C. Ice Load: Load of 3 lbf/sq. ft. (143.6 Pa), applied as stated in AASHTO LTS-4-M Ice load Map.

D. Wind Load: Pressure of wind on pole and luminaire, calculated and applied as stated in AASHTO LTS-4-M.

1. Wind speed for calculating wind load for poles 50 feet (15 m) or less in height is 110 mph (177 km/h).

1.6 REFERENCES

A. ANSI/NFPA 70, National Electrical Code

B. IEEE C62.41, Guide on the Surge Environment in Low-Voltage (1000 V and Less) AC Power Circuits

C. FCC 47 CFR Part 15, Federal Code of Regulation (CFR) testing standard for electronic equipment

D. IESNA LM-79, Electrical and Photometric Measurements of Solid-State Lighting Products

E. IESNA LM-80, Approved Method for Measuring Lumen Maintenance of LED Light Sources

F. IESNA TM-15, Luminaire Classification System for Outdoor Luminaires

G. IESNA TM-21-11, Projecting Long Term Lumen Maintenance of LED Light Sources

H. UL1598, Standard for Safety of Luminaires

I. NEMA SSL 3-2010, High-Power White LED Binning for General Illumination

1.7 DRAWINGS

A. The drawings, which constitute a part of these specifications, indicate the general location of the luminaires.

B. Specifications and drawings are for assistance and guidance, but exact locations, distances and levels will be governed by actual field conditions. Contractor is directed to make field surveys as part of his work prior to submitting system layout drawings.

1.8 QUALITY ASSURANCE

A. Luminaires shall be fully assembled and individually electrically tested prior to shipment.

B. Manufacturers of LED luminaires shall demonstrate a suitable testing program incorporating high heat, high humidity and thermal shock test regimens to ensure system reliability and to substantiate lifetime claims.

C. The sole use of IESNA LM-80 data to predict luminaire lifetime is not acceptable.

D. At time of manufacture, electrical and light technical properties shall be recorded for each luminaire. At a minimum, this should include lumen output, CCT, and CRI. Each luminaire shall utilize a unique serial numbering scheme. Technical properties must be made available for a minimum of 5 years after the date of manufacture.

E. Mockups: Provide exterior lighting fixtures for mock-ups. complete with power and control connections.

1. Provide fixture types as needed for architectural mock-ups in the quantity required to adequately demonstrate installation and performance of the fixtures as specified. These fixtures shall be connected so that the power feeds connecting fixtures is indicative of the completed Work.
2. The final mock-up requirements shall be confirmed on site.

1.9 SUBMITTALS

A. Product Data: For each luminaire, pole, and support component, arranged in order of lighting unit designation. Include data on features, accessories, finishes, and the following:

1. Physical description of luminaire, including materials, dimensions, effective projected area, and verification of indicated parameters.
2. Details of attaching luminaires and accessories.
3. Details of installation and construction.
4. Luminaire materials.
5. Photometric data based on laboratory tests of each luminaire type, complete with indicated lamps, ballasts, and accessories.
   a. Testing Agency Certified Data: For indicated luminaires, photometric data shall be certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.
6. Photoelectric relays.
7. Ballasts, including energy-efficiency data.
8. Lamps, including life, output, CCT, CRI, lumens, and energy-efficiency data.
9. Materials, dimensions, and finishes of poles.
10. Means of attaching luminaires to supports, and indication that attachment is suitable for components involved.
11. Anchor bolts for poles.
12. Manufactured pole foundations.

B. Shop Drawings: Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each Held connection.
2. Anchor-bolt templates keyed to specific poles and certified by manufacturer.

3. Design calculations, certified by a qualified professional engineer, indicating strength of screw foundations and soil conditions on which they are based.
4. Wiring Diagrams: For power, signal, and control wiring.

C. Photometric layouts are required prior to the approval of the product data. Provide point-by-point calculations to include all exterior light fixtures.

1. Provide photometric layout using industry approved lighting software.

1.10 SUBSTITUTIONS

A. The light fixture package specified on the drawings has been certified by a third party employed by the Owner/Utility Company for the purpose of computing utility company rebates to the owner.

1. The Electrical Contractor will employ and pay for the services of the third party designated by the Utility Company to evaluate the substituted fixture package and to compute utility company rebates to the owner.
2. The Utility Company rebates to the Owner shall be equal to or greater than the specified fixture package.
3. Once the substituted package is certified it shall be submitted to the Engineer for approval.
   a. Provide point-by-point lighting calculations of the entire building and site.
   b. Provide Total Light Power Density (LPD) per floor and for the whole building.
   c. The LPD of the substituted luminaires shall be less than or equal to the specified luminaires.

4. Provide a side-by-side comparison between the specified and the substituted fixtures include the following criteria:
   a. Input Watts
   b. Voltage
   c. Output Lumens
   d. Energy Star Rating
   e. DLC approval
   f. Total Light Power Density (LPD) per floor and for the whole building.

1.11 DELIVERY, STORAGE AND HANDLING

A. Package aluminum poles for shipping according to ASTM B 660.

B. Store poles on decay resistant treated skids at least 12 inches (300 mm) above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.

C. Handle wood poles so they will not be damaged. Do not use pointed tools that can indent pole surface more than 1/4 inch (6 mm) deep. Do not apply tools to section of pole to be installed below ground line.

D. Ship equipment in its original packages to prevent damage or entrance of foreign matter. All handling performed in accordance with manufacturers recommendations. Provide protective coverings during construction.

E. Replace, at no expense to Owner, equipment or material damaged during storage or installation as directed by the Architect.

1.12 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

C. Luminaires shall be provided with a 5-year warranty covering, LEDs, drivers and paint finish.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers, products represented by the following rep firms:

1. Reflex Lighting.
2. Apex Lighting.
3. Boston Light Source.
4. Omnilite | Illuminate.
5. Or approved equal.

B. Basis of Design products shall be by Reflex Lighting.

2.2 GENERAL REQUIREMENTS FOR LUMINAIRES

A. Luminaires shall comply with UL 1598 and be listed and labeled for installation in wet locations by an NRTL acceptable to authorities having jurisdiction.

1. l.KR Tests Incandescent Fixtures: Where LKR is specified, test according to NF.MA LE 5A.
2. LER Tests Fluorescent Fixtures: Where LER is specified, test according to NEMA LE 5 and NEMA LE 5A as applicable.
3. LER Tests HID Fixtures: Where LER is specified, test according to NEMA LE 5B.
4. Where LED Fixtures are used: Performance tested per LM-79 and TM-15 (IESNA) certifying its photometric performance. Luminaire designed with 0% uplight (U0 per IESNA TM-15).

B. Lateral Light Distribution Patterns: Comply with IESNA RP-8 for parameters of lateral light distribution patterns (e.g. Type II, Type III. Type IV) indicated for luminaires.

C. Metal Paris: Free of burrs and sharp corners and edges.

D. Sheet Metal Components: Corrosion-resistant aluminum unless otherwise indicated. Form and support to prevent warping and sagging.

E. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.

F. Doors. Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses. Designed to disconnect ballast when door opens.

G. Exposed Hardware Material: Stainless steel.

H. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

I. Light Shields: Metal baffles, factory installed and Held adjustable, arranged to block light distribution to indicated portion of normally illuminated area or field.

J. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:

1. While Surfaces: 85 percent.
2. Specular Surfaces: 83 percent.
3. Diffusing Specular Surfaces: 75 percent.

K. Lenses and Refractors Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

L. Luminaire Finish: Manufacturer's standard paint or custom finish where indicated applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.

M. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps and drivers. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp and ballast characteristics:
   a. CCT and CRI for all luminaires.

2.3 LIGHT EMITTING DIODES (LEDS)

A. 80+ CRI. Chromaticity Tolerance shall be no more than 0.03 on the CIE chromaticity diagram from the black body curve unless otherwise indicated.

B. All exterior lighting shall be 3000K CCT unless otherwise noted in the Luminaire Schedule.

C. 50,000 hours with 70% Lumen maintenance (per IRS LM-80-08), unless otherwise noted in the Luminaire Schedule.

D. LED system shall use 16-bit or greater nonlinear scaling techniques for high-resolution output.

E. All hardwired connections lo LED fixtures shall be reverse polarity protected and provide high voltage protection in the event connections are reversed or shorted during the installation process.

F. Power/data supply outputs shall have current limiting protection. Power/data supply shall provide mis-wiring protection.

G. Power/data supply shall have power factor correction.

H. Both LED module and driver shall be able to be replaced without soldering or sending the luminaire the luminaire back to the manufacturer. Quick-connect devices are preferred.

2.4 LED DRIVERS AND DIMMING CONTROLLERS

A. Dimming:

1. Acceptable means of dimming unless otherwise noted in Fixture Schedule:
   a. Pulse Width Modulation and hybrid Pulse Width Modulation with Constant Current.

2. Continuously from 100% to 1% unless otherwise noted in the Exterior Luminaire Schedule and the specified performance requirements. Driver shall start LED at any dimming position.

B. Operation:

1. Driver shall automatically shut down in case of LED failure condition.
2. Driver shall be provided with mis-wire protection circuitry.
3. Driver shall be provided with short circuit and open circuit protection circuitry.
4. Driver shall contain automatic restart circuitry in order to restart LF.Ds after LF.D
5. replacement.
6. Driver Power Factor at full light output shall be greater than 0.98.
7. Driver Power Factor across dimming range shall be greater than 0.90.

C. Life:

1. 70,000 hours lifetime, minimum.
2. Driver failure rate per 1000 hours operating at 60 degrees Celsius ambient, shall be 0.2 percent or less.

D. Input: 120-277V. 50-60 Hz.

E. Supply: 24VDC constant current (unless otherwise specified).

2.5 LUMINAIRE-MOUNTED PHOTOELECTRIC RELAYS

A. Comply with UL 773 or UL 773A.

B. Contact Relays: Factory mounted, single throw, designed to fail in the on position, and factory set to turn light unit on at 1.5 to 3 (c (16 to 32 lx) and off at 4.5 to 10 fc (48 to 108 lx) with 15-second minimum time delay. Relay shall have directional lens in front of photocell to prevent artificial light sources from causing false turnoff.

1. Relay with locking-type receptacle shall comply with ANSI CI36.10. Adjustable window slide for adjusting oil-off set points.

2.6 GENERAL REQUIREMENTS FOR POLES AND SUPPORT COMPONENTS

A. Structural Characteristics: Comply with AASIITO LTS-4-M.

1. Wind-Load Strength of Poles: Adequate at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of speed indicated in "Structural Analysis Criteria for Pole Selection" Article.
2. Strength Analysis: For each pole, multiply the actual equivalent projected area of luminaires and brackets by a factor of 1.1 to obtain the equivalent projected area to be used in pole selection strength analysis.

B. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts unless otherwise indicated.

C. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.

1. Materials: Shall not cause galvanic action at contact points.
2. Anchor Bolts, Leveling Nuts. Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.
3. Anchor-Bolt Template: Plywood or steel.

D. Handhole: Oval-shaped, with minimum clear opening of 2-1/2 by 5 inches (65 by 130 mm), with cover secured by stainless-steel captive screws.

E. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Concrete, reinforcement, and formwork are specified in Section 033000 "Cast-in-PIace Concrete."

F. Power-Installed Screw Foundations: Factory fabricated by pole manufacturer, with structural steel complying with ASTM A 36/A 36M and hot-dip galvanized according to ASTM A 123/A 123M; and with top-plate and mounting bolts to match pole base flange and strength required to support pole, luminaire, and accessories.

G. Breakaway Supports: Frangible breakaway supports, tested by an independent testing agency acceptable to authorities having jurisdiction, according to AASHTO LTS-4-M.

2.7 ALUMINUM POLES

A. Poles: Seamless, extruded structural tube complying with ASTM B 429 B 429M, Alloy 6063-T6 with access handhole in pole wall.

B. Poles: ASTM B 209 (ASTM B 209M>. 5052-H34 marine sheet alloy with access handhole in pole wall.

1. Shape: [Round, tapered] [Round, straight] [Square, tapered] [Square, straight].
2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.

C. Pole-Top Tenons: Fabricated to support luminaires or luminaires and brackets indicated, and securely fastened to pole top.

D. Grounding and Bonding Lugs: Welded 1/2-inch (13-mm) threaded lug, complying with requirements in Section 260526 "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.

E. Brackets for Luminaires: Detachable, with pole and adapter fittings of cast aluminum. Adapter fitting welded to pole and bracket, then bolted together with stainless-steel bolts.

1. Tapered oval cross section, with straight tubular end section to accommodate luminaire.
2. Finish: Same as pole.

F. Aluminum Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20; and seal aluminum surfaces with clear, hard-coat wax.
3. Class I, Clear Anodic Finish: AA-M32C22A4I (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
4. Class I, Color Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 611.

2.8 POLE ACCESSORIES

A. Duplex Receptacle: 120 V, 20 A in a weatherproof assembly complying with Section 262726 "Wiring Devices" for ground-fault circuit-interrupter type,

1. Recessed, 12 in. (300 mm) above finished grade.
2. Reinforced fiberglass weatherproof while-in-use cover with color to match pole, that when mounted results in NEMA 250 enclosure.
3. With cord opening.
4. With lockable hasp and latch that complies with OSHA lockout and tag-out requirements.

B. Minimum 1800-W transformer, protected by replaceable fuses, mounted behind access cover.

C. Base Covers: Manufacturers' standard metal units, arranged to cover pole's mounting bolts and nuts. Finish same as pole.

D. Transformer Type Base: Same material and color as pole. Coordinate dimensions to suit pole's base flange and accept ballasts and indicated accessories.

2.9 POLE FOUNDATIONS

A. Anchor bolts shall be steel rod having a minimum yield strength of 344.5 MPa (50,000 psi) 50,000 psi; the top 305 mm (12 inches) 12 inches of the rod shall be galvanized in accordance with ASTM A 153/A 153M. Concrete shall be as specified in Division 03.

PART 3 - EXECUTION

3.1 LUMINAIRE INSTALLATION

A. Install lamps in each luminaire.

B. Fasten luminaire to indicated structural supports.

1. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.

C. Adjust luminaires that require field adjustment or aiming.

3.2 POLE INSTALLATION

A. Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on the pole.

B. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features, unless otherwise indicated on Drawings:

1. Fire Hydrants and Storm Drainage Piping: 60 inches (1520 mm).
2. Water, Gas, Electric, Communication, and Sewer Lines: 10 feet (3 m).

C. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Division 03.

D. Foundation-Mounted Poles: Mount pole with leveling nuts and tighten top nuts to torque level recommended by pole manufacturer.

1. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.
2. Grout void between pole base and foundation. Use non-shrink or expanding concrete grout firmly packed to fill space.
3. Install base covers, unless otherwise indicated.
4. Use a short piece of 1/2-inch- (13-mm-) diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.

E. Embedded Poles with Tamped Earth Backfill: Set poles to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height.

1. Dig holes large enough to permit use of tampers in the full depth of hole.
2. Backfill in 6-inch (150-mm) layers and thoroughly tamp each layer so compaction of backfill is equal to or greater than that of undisturbed earth.

F. Embedded Poles with Concrete Backfill: Set poles in augured holes to depth below finished grade indicated on Drawings, but not less than one-sixth of pole height.

1. Make holes 6 inches (150 mm) in diameter larger than pole diameter.
2. Fill augured hole around pole with air-entrained concrete having a minimum compressive strength of 3000 psi (20 MPa) at 28 days, and finish in a dome above finished grade.

3. Use a short piece of 1/2-inch- (13-mm-) diameter pipe to make a drain hole through concrete dome. Arrange to drain condensation from interior of pole.
4. Cure concrete a minimum of 72 hours before performing work on pole.

G. Poles and Pole Foundations Set in Concrete Paved Areas: Install poles with minimum of 6-inch- (150-mm-) wide, unpaved gap between the pole or pole foundation and the edge of adjacent concrete slab. Fill unpaved ring with pea gravel to a level 1 inch (25 mm) below top of concrete slab.

H. Raise and set poles using web fabric slings (not chain or cable).

3.3 BOLLARD LUMINAIRE INSTALLATION

A. Align units for optimum directional alignment of light distribution.

B. Install on concrete base with top 4 inches (100 mm) above finished grade or surface at bollard location. Cast conduit into base, and shape base to match shape of bollard base. Finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 03.

3.4 INSTALLATION OF INDIVIDUAL GROUND-MOUNTING LUMINAIRES

A. Install on concrete base with top 4 inches (100 mm) above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 03.

3.5 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

B. Steel Conduits: Comply with Division 26. In concrete foundations, wrap conduit with 0.010-inch-(0.254-mm-) thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.6 GROUNDING

A. Ground metal poles and support structures according to Division 26.

1. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.

3.7 TRAINING AND SERVICE

A. Comply with Section 260001.

B. Conduct two 4-hour training sessions. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

End of Section

Section 26 56 68

EXTERIOR ATHLETIC FIELD LIGHTING

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

ALTERNATE #2

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. Work covered by this section of the specifications shall conform to the contract documents, engineering plans as well as state and local codes.

B. The purpose of these specifications is to define the lighting system performance and design standards for the Doherty Memorial High School lighting project using an LED Lighting source. The manufacturer / contractor shall supply lighting equipment to meet or exceed the standards set forth in these specifications.

C. The sports lighting will be for the following venues:

1. Football

D. The primary goals of this sports lighting project are:

1. Guaranteed Light Levels: Selection of appropriate light levels impact the safety of the players and the enjoyment of spectators. Therefore, light levels are guaranteed to not drop below specified target values for a period of 25 years.
2. Environmental Light Control: It is the primary goal of this project to minimize spill light to adjoining properties and glare to the players, spectators, and neighbors.
3. Control and Monitoring: To allow for optimized use of labor resources and avoid unneeded operation of the facility, customer requires a remote on/off control system for the lighting system. Fields should be proactively monitored to detect luminaire outages over a 25-year life cycle. All communication and monitoring costs for 25-year period shall be included in the bid.

E. All manufacturers, regardless of approval, must demonstrate that they meet all performance and quality specifications as outlined herein. Systems that do not meet all the performance and quality specifications specified herein shall not be accepted.

1.4 SUBMITTALS

A. Complete bill of material and current brochures/cut sheets for all products being provided. Listing of all information being submitted must be included on the table of contents. List the name of the manufacturer's local representative and his/her phone number.

B. Drawing(s) showing field layouts with pole locations.

C. Lighting design drawing(s) showing:

1. Field Name, date, file number, prepared by
2. Outline of field(s) being lighted, as well as pole locations referenced to the center of the field (x & y), Illuminance levels at grid spacing specified
3. Pole height, number of fixtures per pole, horizontal and vertical aiming angles, as well as luminaire information including wattage, lumens and optics
4. Height of light test meter above field surface.
5. Summary table showing the number and spacing of grid points; average, minimum and maximum illuminance levels in foot candles (fc); uniformity including maximum to minimum ratio, coefficient of variance (CV), coefficient of utilization (CU) uniformity gradient; number of luminaries, total kilowatts, average tilt factor; light loss factor.
6. Lighting design drawing showing initial spill light levels along the boundary line (defined on bid drawings) in footcandles. Lighting design showing glare along the boundary line in candela. Light levels shall be taken at 30-foot intervals and 3-feet above grade along the boundary line. Readings shall be taken with the meter orientation at both horizontal and aimed towards the most intense bank of lights.
7. Provide first page of photometric report for all luminaire types being proposed showing candela tabulations as defined by IESNA Publication LM-35-02. Photometric data shall be certified by laboratory with current National Voluntary Laboratory Accreditation Program or an independent testing facility with over 5 years experience. Ball Tracking luminaries are excluded from this qualification.

D. Provide performance guarantee including a written commitment to undertake all corrections required to meet the performance requirements noted in these specifications at no expense to the owner. Light levels must be guaranteed to not fall below target levels for warranty period.

E. Pole structural calculations and foundation design showing foundation shape, depth backfill requirements, rebar, and anchor bolts (if required). Pole base reaction forces shall be shown on the foundation drawing along with soil bearing pressures. Design must be stamped by a structural engineer in the state of Massachusetts, if required by owner.

F. Manufacturer of the control and monitoring system shall provide written definition and schematics for automated control system.

G. Provide written warranty information including all terms and conditions.

H. Manufacturer to provide a list of ten (10) projects where the technology and specific fixture proposed for this project has been installed in the state of Massachusetts. Reference list will include project name, project city, installation date, and if requested, contact name and contact phone number.

I. Manufacturer shall supply an expected delivery timeframe from receipt of approved submittals and complete order information.

J. Manufacturer shall list all items that do not comply with the specifications.

1.5 LIGHTING PERFORMANCE

A. Illumination Levels and Design Factors: Playing surfaces shall be lit to an average target illumination level and uniformity as specified in the chart below. Lighting calculations shall be developed, and field measurements taken on the grid spacing with the minimum number of grid points specified below. Appropriate light loss factors shall be applied and submitted for the basis of design. Average illumination level shall be measured in accordance with the IESNA LM-5-04 (IESNA Guide for Photometric Measurements of Area and Sports Lighting Installations). Illumination levels shall not to drop below desired target values in accordance to IES RP-6-15, Page 2, Maintained Average Illuminance and shall be guaranteed for the full warranty period.

Area of Lighting	Average Target Illumination Levels	Maximum to Minimum Uniformity Ratio	Grid Points	Grid Spacing
Football	50FC	2:1	72	30’ x 30’
Bleachers	> 15FC	6.5:1	93	10’ x 10

NOTE: F1 and F2 shall have (1) 400w luminaire on a dedicated security circuit.

B. Color: The lighting system shall have a minimum color temperature of 5700K and a CRI of 75+.

C. Mounting Heights: To ensure proper aiming angles for reduced glare and to provide better playability, minimum mounting heights shall be as described below. Higher mounting heights may be required based on photometric report and ability to ensure the top of the field angle is a minimum of 10 degrees below horizontal.

# of Poles	Pole Designation	Pole Height
4	F1-F4	80’

1.6 ENVIRONMENTAL LIGHT CONTROL

A. Light Control Luminaires: All luminaires shall utilize spill light and glare control devices including, but not limited to, internal shields, louvers, and external shields. No symmetrical beam patterns are accepted.

B. Spill Light and Glare Control: To minimize impact on adjacent properties, spill light and candela values must not exceed the following levels taken at 3 feet above grade.

Residential Line	Maximum
Horizontal Footcandles	< ¾ FC
Vertical Footcandles	< ½ FC
Candela	< 3000 CD

C. Spill Scans: Spill scans must be submitted indicating the amount of horizontal and vertical footcandles along the specified lines. Light levels shall be taken at 30-foot intervals along the boundary line. Readings shall be taken with the meter orientation at both horizontal and aimed

towards the most intense bank of lights. Illumination level shall be measured in accordance with the IESNA LM-5-04 after 1 hour warm up.

D. The first page of a photometric report for all luminaire types proposed showing horizontal and vertical axial candle power shall be provided to demonstrate the capability of achieving the specified performance. Reports shall be certified by a qualified testing laboratory with a minimum of five years' experience or by a manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products. A summary of the horizontal and vertical aiming angles for each luminaire shall be included with the photometric report.

1.7 WARRANTY

A. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

B. Manufacturer's Warranty

1. 25-Year Warranty: Each manufacturer shall supply a signed warranty covering the entire system for 25 years from the date of shipment. The warranty shall be active regardless if specified product is no longer available. In the event specified product is no longer available, manufacturer shall replace materials with current or equal product. Warranty shall guarantee specified light levels. Manufacturer shall maintain specifically funded financial reserves to assure fulfillment of the warranty for the full term. Warranty does not cover weather conditions events such as lightning or hail damage, improper installation, vandalism or abuse, unauthorized repairs or alterations, or product made by other manufacturers.
2. Maintenance: Manufacturer shall monitor the performance of the lighting system, including on/off status, hours of usage and luminaire outage for 25 years from the date of equipment shipment. Parts and labor shall be covered such that individual luminaire outages will be repaired when the usage of any field is materially impacted. Manufacturer is responsible for removal and replacement of failed luminaires, including all parts, labor, shipping, and equipment rental associated with maintenance. Manufacturer shall be responsible for any freight and labor charges to dismantle and return/exchange faulty equipment. Owner agrees to check fuses in the event of a luminaire outage.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. The basis of design product shall be Musco's Light-Structure System™ with TLC for LED™.

2.2 SPORTS LIGHTING SYSTEM CONSTRUCTION

A. Manufacturing Requirements: All components shall be designed and manufactured as a system. All luminaires, wire harnesses, drivers and other enclosures shall be factory assembled, aimed, wired, and tested.

B. Durability: All exposed components shall be constructed of corrosion resistant material and/or coated to help prevent corrosion. All exposed carbon steel shall be hot dip galvanized per ASTM A123. All exposed aluminum shall be powder coated with high performance polyester or anodized. All exterior reflective inserts shall be anodized, coated, and protected from direct

environmental exposure to prevent reflective degradation or corrosion. All exposed hardware and fasteners shall be stainless steel of 18-8 grade or better, passivated and coated with aluminum-based thermosetting epoxy resin for protection against corrosion and stress corrosion cracking. Structural fasteners may be carbon steel and galvanized meeting ASTM A153 and ISO/EN 1461 (for hot dipped galvanizing), or ASTM B695 (for mechanical galvanizing). All wiring shall be enclosed within the cross-arms, pole, or electrical components enclosure.

C. System Description: Lighting system shall consist of the following:

1. Galvanized steel poles and cross-arm assembly.
2. Non-approved pole technology:
   a. Square static cast concrete poles will not be accepted.
   b. Direct bury steel poles which utilize the extended portion of the steel shaft for their foundation will not be accepted due to potential for internal and external corrosive reaction to the soils and long-term performance concerns.

3. Lighting systems shall use concrete foundations. See Section 2.4 for details.
   a. For a foundation using a pre-stressed concrete base embedded in concrete backfill the concrete shall be air-entrained and have a minimum compressive design strength at 28 days of 3,000 PSI. 3,000 PSI concrete specified for early pole erection, actual required minimum allowable concrete strength is 1,000 PSI. All piers and concrete backfill must bear on and against firm undisturbed soil.
   b. For anchor bolt foundations or foundations using a pre-stressed concrete base in a suspended pier or reinforced pier design pole erection may occur after 7 days. Or after a concrete sample from the same batch achieves a certain strength.

4. Manufacturer will supply all drivers and supporting electrical equipment.
   a. Remote drivers and supporting electrical equipment shall be mounted approximately 10 feet above grade in aluminum enclosures. Enclosures more than halfway up the pole will not be accepted. The enclosures shall be touch-safe and include drivers and fusing with indicator lights on fuses to notify when a fuse is to be replaced for each luminaire. Disconnect per circuit for each pole structure will be located in the enclosure. Integral drivers are not allowed.
   b. Manufacturer shall provide surge protection at the pole equal to or greater than 40 kA for each line to ground (Common Mode) as recommended by IEEE C62.41.2_2002.

5. Wire harness complete with an abrasion protection sleeve, strain relief and plug-in connections for fast, trouble-free installation.
6. All luminaires, visors, and cross-arm assemblies shall withstand 150 mph winds and maintain luminaire aiming alignment.
7. Control cabinet to provide remote on-off control, monitoring of the lighting system. See Section 2.3 for further details.
8. Manufacturer shall provide lightning grounding as defined by NFPA 780 and be UL Listed per UL 96 and UL 96A.
   a. Integrated grounding via concrete encased electrode grounding system.
   b. If grounding is not integrated into the structure, the manufacturer shall supply grounding electrodes, copper down conductors, and exothermic weld kits. Electrodes and conductors shall be sized as required by NFPA 780.The grounding electrode shall be minimum size of 5/8 inch diameter and 8 feet long, with a minimum of 10 feet embedment. Grounding electrode shall be connected to the structure by a grounding electrode conductor with a minimum size of 2 AWG for poles with 75 feet mounting height or less, and 2/0 AWG for poles with more than 75 feet mounting height.

D. Safety: All system components shall be UL listed for the appropriate application.

2.3 ELECTRICAL

A. Electric Power Requirements for the Sports Lighting Equipment:

1. Electric power: 480 Volt, 3 Phase.
2. Maximum total voltage drop: Voltage drop to the disconnect switch located on the poles shall not exceed three (3) percent of the rated voltage.

B. Energy Consumption: The kW consumption for the field lighting system shall be 48kW, or less.

2.4 CONTROL

A. Instant On/Off Capabilities: System shall provide for instant on/off of luminaires.

B. Lighting contactor cabinet(s) constructed of NEMA Type 4 aluminum, designed for easy installation with contactors, labeled to match field diagrams and electrical design. Manual off-on-auto selector switches shall be provided.

C. Dimming: System shall provide for 3-stage dimming (high-medium-low). Dimming with be set via scheduling options (Website, app, phone, fax, email). Dimming capabilities shall NOT require a 0-10v DMX converter.

D. Remote Lighting Control System: System shall allow owner and users with a security code to schedule on/off system operation via a web site, phone, fax or email up to ten years in advance. Manufacturer shall provide and maintain a two-way TCP/IP communication link. Trained staff shall be available 24/7 to provide scheduling support and assist with reporting needs.

E. The owner may assign various security levels to schedulers by function and/or fields. This function must be flexible to allow a range of privileges such as full scheduling capabilities for all fields to only having permission to execute “early off” commands by phone. Scheduling tool shall be capable of setting curfew limits.

F. Controller shall accept and store 7-day schedules, be protected against memory loss during power outages, and shall reboot once power is regained and execute any commands that would have occurred during outage.

G. Remote Monitoring System: System shall monitor lighting performance and notify manufacturer if individual luminaire outage is detected so that appropriate maintenance can be scheduled. The controller shall determine switch position (manual or auto) and contactor status (open or closed).

H. Management Tools: Manufacturer shall provide a web-based database and dashboard tool of actual field usage and provide reports by facility and user group. Dashboard shall also show current status of luminaire outages, control operation and service. Mobile application will be provided suitable for IOS, Android and Blackberry devices.

I. Hours of Usage: Manufacturer shall provide a means of tracking actual hours of usage for the field lighting system that is readily accessible to the owner.

1. Cumulative hours: shall be tracked to show the total hours used by the facility.
2. Report hours saved by using early off and push buttons by users.

J. Communication Costs: Manufacturer shall include communication costs for operating the control and monitoring system for a period of 25 years.

K. Communication with luminaire drivers: Control system shall interface with drivers in electrical components enclosures by means of powerline communication.

2.5 STRUCTURAL PARAMETERS

A. Wind Loads: Wind loads shall be based on the 2015 International Building Code. Wind loads to be calculated using ASCE 7-10, an ultimate design wind speed of 130mph and exposure category C.

B. Pole Structural Design: The stress analysis and safety factor of the poles shall conform to 2013 AASHTO Standard Specification for Structural Supports for Highway Signs, Luminaires, and Traffic Signals (LTS-6).

C. Foundation Design: The foundation design shall be based on soil parameters as outlined in the geotechnical report. If no geotechnical report is available, the foundation design shall be based on soils that meet or exceed those of a Class 5 material as defined by 2015 IBC Table 1806.2.

D. Foundation Drawings: Project specific foundation drawings stamped by a registered engineer in the state where the project is located are required. The foundation drawings must list the moment, shear (horizontal) force, and axial (vertical) force at ground level for each pole. These drawings must be submitted at time of bid to allow for accurate pricing.

PART 3 - EXECUTION

3.1 SOIL QUALITY CONTROL

A. It shall be the Contractor’s responsibility to notify the Owner if soil conditions exist other than those on which the foundation design is based, or if the soil cannot be readily excavated. Contractor may issue a change order request / estimate for the Owner’s approval / payment for additional costs associated with:

1. Providing engineered foundation embedment design by a registered engineer in the State of Massachusetts for soils other than specified soil conditions.
2. Additional materials required to achieve alternate foundation.
3. Excavation and removal of materials other than normal soils, such as rock, caliche, etc.

3.2 DELIVERY TIMING

A. Delivery Timing Equipment On-Site: The equipment must be on-site 6-8 weeks from receipt of approved submittals and receipt of complete order information.

3.3 FIELD QUALITY CONTROL

A. Illumination Measurements: Upon substantial completion of the project and in the presence of the Contractor, Project Engineer, Owner's Representative, and Manufacturer's Representative, illumination measurements shall be taken and verified. The illumination measurements shall be conducted in accordance with IESNA LM-5-04.

B. Field Light Level Accountability

1. Light levels are guaranteed not to fall below the target maintained light levels for the entire warranty period of 25 years. These levels will be specifically stated as “guaranteed” on the illumination summary provided by the manufacturer.
2. The contractor/manufacturer shall be responsible for conducting initial light level testing and an additional inspection of the system, in the presence of the owner, one year from the date of commissioning of the lighting (upon request).
3. The contractor/manufacturer will be held responsible for any and all changes needed to bring these fields back to compliance for light levels and uniformities. Contractor/Manufacturer will be held responsible for any damage to the fields during these repairs.

C. Correcting Non-Conformance: If, in the opinion of the Owner or his appointed Representative, the actual performance levels including footcandles and uniformity ratios are not in conformance with the requirements of the performance specifications and submitted information, the Manufacturer’s personal tech crew shall be required to make adjustments to meet specifications and satisfy Owner. No subcontracting the work out will be allowed.

3.4 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup check according to the approved manufacturer's written instructions.

3.5 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct four 4-hour training sessions. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

End of Section

Section 27 05 00

COMMON WORK RESULTS FOR COMMUNICATIONS

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. Section Includes:

1. Telecommunications mounting elements.
2. Backboards.
3. Telecommunications pathways.
4. Grounding.

B. Related Sections:

1. Division 27 Section "Communications Backbone Cabling" for voice and data cabling associated with system panels and devices.
2. Division 27 Section "Communications Horizontal Cabling" for voice and data cabling associated with system panels and devices.

1.4 SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings: For communications equipment room fittings. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies, and location and size of each field connection.
2. Equipment racks and cabinets: Include workspace requirements and access for cable connections.
3. Grounding: Indicate location of grounding bus bar and its mounting detail.

C. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.

1.5 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings shall be under the direct supervision of RCDD.
2. Installation Supervision: Installation shall be under the direct supervision of Registered Technician, who shall be present at all times when Work of this Section is performed at Project site.
3. Field Inspector: Currently registered by BICSI as RCDD to perform the on-site inspection.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Telecommunications Pathways and Spaces: Comply with TIA-569-A.

D. Grounding: Comply with ANSI-J-STD-607-A.

1.6 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install equipment frames and cable trays until spaces are enclosed and weather tight, wet work in spaces is complete and dry, and work above ceilings is complete.

1.7 COORDINATION

A. Coordinate layout and installation of communications equipment with Owner's telecommunications and LAN equipment and service suppliers. Coordinate service entrance arrangement with local exchange carrier.

1. Meet jointly with telecommunications and LAN equipment suppliers, local exchange carrier representatives, and Owner to exchange information and agree on details of equipment arrangements and installation interfaces.
2. Record agreements reached in meetings and distribute them to other participants.
3. Adjust arrangements and locations of distribution frames, cross-connects, and patch panels in equipment rooms to accommodate and optimize arrangement and space requirements of telephone switch and LAN equipment.

1.8 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 RACKS

A. 4-Post 84”H x 19”W x 30”D with 6” vertical cable management. Provide as shown on the contract drawings for telecommunications cabling punch down. Coordinate rack requirements with various system vendors and provide appropriate rack for each system.

B. 2-Post 84” H x 19” W x 18” D with 6” vertical cable management. Provide as shown on the contract drawings for telecommunications cabling punch down. Coordinate rack requirements with various system vendors and provide appropriate rack for each system.

C. 35U” wall mounted pivoting rack. Provide in Fire Command Center.

D. Basis of Design:

1. Hoffman, P/N: EDR19FM45U6, 2-Post Rack
2. Hoffman, P/N: E4DR19FM45U, 4-post, adjustable depth rack with tapped rails.
3. Hoffman DV6D7 Vertical Manager.
4. Hoffman DCHS2 Horizontal Manager.
5. Middle Atlantic Product, P/N: DWR-35-26.

2.2 SERVER CABINETS

A. Features

1. Rigid front door made of aluminum extrusions and formed perforated steel offers highly attractive appearance and durability.
2. Fully perforated front and rear doors and fully perforated top allow maximum air movement around equipment; conforms to server manufacturer open space requirements.
3. Models without sides fit together quickly for easy installation in ganged applications.
4. Three-point locking pushbutton swing handle on front door provides easy but controlled access; two keys included.
5. Rear doors are split for easy access and include 3-point, low profile, locking swing handle.
6. Two sets of 19-in. square-hole rack angles support both front and rear of equipment.
7. Rack angles are infinitely adjustable from front to rear for positioning flexibility.
8. Large gland plate in top allows easy routing of cable, pre-terminated cables, and patch panels.
9. Mounting hardware (20 each of 10-32 screws and cage nuts) is included.

B. Specifications

1. 16 or 14 gauge steel doors, sides and cover.
2. Welded 12 gauge steel frame.
3. Rack angles have square holes with EIA 310-D spacing.
4. Open bottom with integral bolt-down brackets.

C. Finish

1. Pretreated steel coated with RAL 9005 black textured, low-gloss polyester powder paint.

D. Load Rating

1. Static Load Rating: 2500 lb. (1134 kg)

E. Basis of Design

1. Hoffman, P/N: PSCPC21610B, ProLine FloTek PC Server Cabinet.

2.3 BACKBOARDS

A. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches (19 by 1220 by 2440 mm). Comply with requirements for plywood backing panels specified in Division 06.

2.4 PATHWAYS

A. General Requirements: Comply with TIA-569.

B. Cable Support: NRTL labeled for support of communications cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.

1. Installed concealed above accessible ceilings, use the following supports unless otherwise noted:
   a. Wire mesh basket trays.
   b. Support brackets with cable tie slots for fastening cable ties to brackets.
   c. Lacing bars, spools, J-hooks, J-Pros, J-Mods and D-rings.
   d. Straps and other devices.

2. Installed concealed in walls and inaccessible ceilings, use the following supports unless otherwise noted:
   a. EMT raceways to nearest accessible ceiling or wire mesh basket tray.

3. Installed exposed, use the following supports unless otherwise noted:
   a. Wire mesh basket trays.
   b. EMT raceways to telecommunications room, nearest accessible ceiling or wire mesh tray.

C. Conduit and Boxes: Comply with requirements specified in Division 26.

1. Outlet boxes shall be no smaller than 4 inches (100 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep. Provide single gang raise covers.
2. In rated walls provide boxes listed for use in fire rated walls.
3. Back-to-back device boxes shall be staggered so that only one box occupies the wall cavity between two studs. Provide 1” EMT conduit stub with pull string above the accessible ceiling unless otherwise noted.

D. Ladder Trays

1. Provide ladder trays in all telecommunications rooms (IDF/MDF).
2. Secured on 5-foot centers overhead using a standard trapeze type support system with 1/2-inch threaded rod in accordance with manufacturer specifications.
3. Cable tray not to be attached to the walls, secure overhead to a single plane.
4. UL Classified, gold zinc plated and minimum 18-inches wide with 9-inch rung spacing.

5. Installed with a minimum clearance of 12-inches above the cable ladder.
6. Meet the current requirements in ANSI/TIA-569 and applicable addendums.
7. Grounded and bonded in accordance with ANSI/TIA-607. All splices, T-Sections and bends shall be bonded together. Cable runway and trays shall not be used as an equipment ground nor seismic support or bracing.
8. Meet seismic bracing standards.

E. Wire Mesh Basket Trays:

1. Manufacturers:
   a. nVent Caddy
   b. Basofil.
   c. Cablofil Inc.
   d. Or approved equal

2. Wire Mesh Basket Trays
   a. Provide wire basket of types and sizes indicated; with all required splicing and mounting hardware. Construct units with T-weld edges and smooth surfaces; in compliance with applicable standards; and with the following additional construction features.
      1) All straight section longitudinal wires shall be constructed with a continuous top wire safety edge. Safety edge must be T-welded on all tray sizes.
      2) Wire basket cross-wire to be constructed with either flat shaped wire design or with round wire design, as directed by engineer.
         a) Flat shaped cross wire design shall provide additional surface area for cable weight support and to avoid pressure points and strain on cables.
         b) Round shaped cross wire design may be used in general purpose applications where cable weight and strain are not concerns.
   b. Materials and Finishes: Material and finish specifications for Carbon Steel Wire and Pre-Galvanized steel wire are as follows:
      1) Pre-galvanized Zinc: Straight section shall be made from pre-galvanized steel meeting the minimum mechanical properties of ASTM A 641. Material must be cleaned after fabrication to remove any soot, manufacturing residue/oils, or metallic particles.
   c. Wire basket shall be made of high strength steel wires and formed into a standard 2 inch by 4-inch wire mesh pattern with intersecting wires welded together. All mesh sections must have at least one bottom longitudinal wire along entire length of straight section.
   d. Wire basket sizes shall conform to the following nominal criteria:
      1) Straight sections shall be furnished in standard 118-inch lengths.
      2) Wire diameter shall be 0.195" (5mm) minimum on all mesh sections up to 16 linear inches. Wire diameter line wire shall be 0.234" (6mm) minimum on all mesh sections in excess of 16 linear inches. Wire diameter shall be minimum size of 4.5mm on stainless steel.
      3) Wire basket shall have a 4-inch usable loading depth (4), (6), (8), (10), (12), (14), (16), (18), (20), (22), (24), (26), (28) inches wide.
      4) All fillings shall be field formed, from straight sections, in accordance with manufacturer's instructions.
      5) All Tray sections and splicing assemblies shall be UI7C-UL Classified as an Equipment Ground Conductor (EGC).
      6) Wire mesh basket tray supports shall be ceiling trapeze type, center support, trapeze clips, or wall brackets.

7) Special accessories shall be furnished as required to protect, support and install a wire basket support system.

e. Provide wire mesh basket trays where shown on the drawings. The main trunk shall be 18 inches wide by 4 inches deep.

3. Utilize wall-mounted trays when hanger load limitations are met as set forth in detail "TYPICAL HANGER LOAD RESTRICTIONS at COMPOSITE SLABS and ROOF DECK" on drawing S1.03. or provide supplemental steel or Unistrut system.

2.5 GROUNDING

A. Comply with requirements of ANSI/J-STD-607-A.

B. Busbar

1. Telecommunications main grounding busbar (TMGB)
   a. The TMGB shall be a predrilled copper busbar provided with holes for use with standard sized lugs and shall be listed by a nationally recognized testing laboratory (NRTL). The minimum size of the TMGB shall be 6 mm (0.25 in) thick by 100 mm (4 in) wide by a length that is determined by the number of connections (including future growth) that will be required to be made to the busbar (see ANSI/J-STD-607-A). The TMGB shall be insulated from its support attachment a minimum of 50 mm (2 in). Minimum length shall be 14 in.

2. Telecommunications grounding busbar (TGB)
   a. The TGB shall be a predrilled copper busbar provided with holes for use with standard sized lugs (see figure 3) and shall be Listed by an NRTL The minimum size of the TGB shall be 6 mm (0.25 in) thick by 50 mm (2 in) wide by a length that is determined by the number of connections (including future growth) that will be required to be made to the busbar (see ANSI/I-STD-607-A). The TGB shall be insulated from its support attachment a minimum of 50 mm (2 in). Minimum length shall be 10 in.

C. Bonding to the electrical power system

1. The telecommunication bonding and grounding system shall be bonded to the power grounding system either at the service panel grounding busbar or the electrical grounding electrode, as described in ANSI/J-STD-607-A.

D. Bonding conductor

1. Bonding conductors shall be insulated stranded copper or flat braided copper and shall be Listed for the space in which they are intended to be placed according to the NEC® (e.g., plenum spaces, riser spaces), unless otherwise specified. When conductors are insulated, the jacket shall be green, green with a yellow stripe, or marked with green tape or a green adhesive label.

E. Telecommunications bonding backbone (TBB)

1. The TBB connects the TMGB to the telecommunications grounding busbars (TGBs). The TBB shall be a continuous green insulated copper conductor that should be sized no less than 3/0 AWG.

F. Grounding equalizer (GE)

1. The GE connects the telecommunications grounding busbar(s) in the same-floor telecommunications rooms (TRs) on the first, top, and every third floor in a multistory building. The GE shall be a continuous green insulated copper conductor that should be sized no less than 3/0 AWG.
2. NOTE: Cable shields do not satisfy the requirements for a GE.

G. Bonding connections

1. Bonding connections shall be made by means of a compression connector or an exothermic weld. Compression connectors shall have only one conductor installed unless designed or Listed for more conductors. Compression and exothermically welded connections are irreversible, can withstand multiple fault currents, and will not loosen. Mechanical connections are only allowed when connecting a conductor to equipment, raceways, cable trays, water pipe, and similar appurtenances or when a compression or exothermic connection cannot be made. Connections to the TMGB/TGB shall use exothermically welded connections or two-hole lug connectors. Two-hole lug connections can be compression connectors or exothermically welded connectors.

H. Connections to the TMGB/TGB

1. Electrical distribution panel (EDP)
   a. When an EDP is located in the same room as the TMGB/TGB, that EDP's equipment grounding bus or the panel board enclosure shall be bonded to the TMGB/TGB using green insulated bonding conductors sized no less than 6 AWG to a maximum 3/0 AWG.

2. Building steel
   a. Where building steel is accessible and in the same room as the TMGB/TGB, the TMGB/TGB shall be bonded to building steel using a minimum 6 AWG green insulated conductor. When the building steel is external to the room but readily accessible, it should be bonded to the TMGB/TGB. Building steel should be tested to verify its ground conductivity to earth.
   b. NOTE: Modern building construction techniques will ground building steel to the main ac power entrance or another grounding source. Ensure that when working in existing buildings that the building steel is bonded to a suitable ground source (e.g., electrical power grounding electrode[s], building ground ring).

3. Conduit
   a. In order to limit the potential difference between telecommunications conduits and telecommunications conduits and power conduits, the telecommunications conduits shall be bonded to the TMGB/TGB.

4. Telecommunications equipment bonding conductor (TEBC)
   a. The TEBC shall be exothermically welded or connected, using either a compression style or exothermic style two-hole lug, to the connection point on the TMGB/TGB.

5. Bonding equipment, racks and cabinets
   a. The TMGB/TGB shall be bonded to equipment, racks and cabinets using a minimum 6 AWG green insulated conductor.

6. All cable tray, ladder rack, and access floors shall be grounded/bonded to the Telecommunications Grounding Busbar (TGB). All aforementioned telecommunications components shall be grounded/bonded to the TGB using stranded 6 AWG green insulated conductor. Cable tray and ladder rack runs shall be grounded/bonded per the manufacturer's instructions. At a minimum the cable tray and ladder rack shall be grounded/bonded to the building steel every 50 ft.

2.6 FIRE RATE SLEEVES

A. Penetration pathways required for low voltage cabling shall meet the following requirements:

1. Meet the hourly fire-rating of fire rated wall and or floor penetrated.
2. Be tested for the surrounding construction and cable types involved.
3. Have UL Systems permitting cable loads from; "Zero to 100% Visual Fill." This requirement eliminates need for fill-ratio calculations to be made by cable technicians to ensure cable load is within maximum allowed by UL System.
4. Not have inner fabric liner that tightens around and compresses cables tightly together encouraging potential cable damage or interference.
5. Be "Zero-Maintenance", zero-maintenance is defined as; No action required by cabling technician to open and/or close pathway for cable moves, adds or changes, such as, but not limited to:
    a. Opening or closing of doors.
    b. Spinning rings to open or close fabric liner.
    c. Removal and or replacement of any material such as, but not limited to, firestop caulk, putty, pillows, bags, foam muffins, foam, foam plugs, foam blocks, or foam closures of any sort.
    d. Evaluation Services Report (ESR) from an accredited Nationally Recognized Third-party Laboratory certifying compliance with this definition of "Zero-Maintenance" and all relevant codes and standards.
6. Penetration pathways shall be engineered such that two or more devices may be ganged together for larger cable capacities.
7. Penetration pathways shall be engineered to be re-enterable so they can be retrofitted and removed from around existing cables without cutting and re-splicing them.
8. Cable Pathway Devices passing vertically through floors shall have equal F & T Rating.
9. Affix adhesive wall label immediately adjacent to devices to communicate to future cable technicians, authorities having jurisdiction and others the manufacturer of the device and the corresponding.

B. Fire Rated Cable Pathways: Gangable device modules capable of being retrofitted around existing cables and comprised of steel raceway with intumescent foam pads allowing 0 to 100 percent cable fill and requiring no additional action in the form of plugs, twisting closure, putty, pillow, or sealant to achieve fire and leakage ratings.

1. Manufacturers
    a. Specified Technologies Inc. (STI) EZ-Path Fire Rated Pathway
    b. Legrand FlameStopper thru-wall fittings
    c. Hilti Speed Sleeve CP 653
    d. Or approved equal

2. Basis of Design
    a. The system specified is based upon products by STI and represents the performance standard upon which any equivalent solution shall be based.

1) 4” – EZ-Path Series 44+
2) 2” – EZ-Path Series 22

3. Applications
   a. Telecommunications room floor penetrations:
      1) Provide a minimum of 4-4” fire rated penetrations unless otherwise noted.
   b. Telecommunications room ceiling penetrations:
      1) Provide a minimum of 4-4” fire rated penetrations unless otherwise noted.
   c. Telecommunications room wall penetrations:
      1) Provide a minimum of 4-4” fire rated penetrations unless otherwise noted.
   d. Rooms accessible from corridors:
      1) Provide a minimum of 1-2” fire rated penetration from the corridor to each classroom or office unless otherwise noted.
   e. Fire rated corridor walls in corridors:
      1) Provide a minimum of 4-4” fire rated penetrations unless otherwise noted.

2.7 LABELING

A. Comply with TIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

PART 3 - EXECUTION

3.1 ENTRANCE FACILITIES

A. Contact telecommunications service provider and arrange for installation of demarcation point, protected entrance terminals, and a housing when so directed by service provider.

B. Install underground pathways complying with recommendations in TIA-569-A, "Entrance Facilities" Article.

C. Install underground entrance pathway complying with Division 26 Section "Raceway and Boxes for Electrical Systems."INSTALLATION

D. Comply with NECA 1.

E. Comply with BICSI TDMM for layout and installation of communications equipment rooms.

F. Cable Trays: Comply with NEMA VE 2 and TIA-569-A-7.

G. Bundle, lace, and train conductors and cables to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.2 GROUNDING

A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. Comply with ANSI-J-STD-607-A.

C. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.3 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA-606-A. Comply with requirements in Division 26 Section "Identification for Electrical Systems." Comply with requirements in Division 09 Section "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.

B. See Division 27 Section "Communications Horizontal Cabling" for additional identification requirements. See Evaluations for discussion of TIA standard as it applies to this Section. Paint and label colors for equipment identification shall comply with TIA-606-A for Class 2 level of administration.

C. Labels shall be preprinted or computer-printed type.

End of Section

Section 27 13 00

COMMUNICATIONS BACKBONE CABLING

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. Section Includes:

1. Pathways.
2. UTP cable.
3. 50/125-micrometer, optical fiber cabling.
4. Single mode optical fiber cabling.
5. Cable connecting hardware, patch panels, and cross-connects.
6. Cabling identification products.

B. Related Sections:

1. Division 27 for voice and data cabling associated with system panels and devices.

1.4 DEFINITIONS

A. BICSI: Building Industry Consulting Service International.

B. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.

C. EMI: Electromagnetic interference.

D. IDC: Insulation displacement connector.

E. LAN: Local area network.

F. RCDD: Registered Communications Distribution Designer.

G. UTP: Unshielded twisted pair.

1.5 CODES AND STANDARDS

A. Complete installation shall meet or exceed the latest edition of following standards:

1. TIA-568: Commercial building telecommunications wiring standard and all current addenda.
2. TIA-569: Commercial building standard for telecommunications pathways and spaces.
3. TIA-606: Administration standard for telecommunications infrastructure of commercial buildings.
4. TIA-607: Commercial building grounding and bonding requirements for telecommunications.
5. ANSI, ASTM, UL, NEMA, IEEE and FCC standards as applicable.
6. BICSI Telecommunications Distribution Methods Manual, current edition.

1.6 BACKBONE CABLING DESCRIPTION

A. Backbone cabling system shall provide interconnections between telecommunications closet/room, data center, and entrance facilities (demark room) in the telecommunications cabling system structure. Cabling system consists of backbone cables, intermediate and main cross-connects, mechanical terminations, and patch cords or jumpers used for backbone-to-backbone cross-connection.

B. Backbone cabling cross-connects may be located in communications equipment rooms or at entrance facilities. Bridged taps and splitters shall not be used as part of backbone cabling.

1.7 PERFORMANCE REQUIREMENTS

A. General Performance: Backbone cabling system shall comply with transmission standards in TIA-568, when tested according to test procedures of this standard.

1.8 SUBMITTALS

A. Comply with requirements specified in Division 01.

B. Shop Drawings

1. Prior to assembling or installing the system, the Contractor shall provide complete shop drawings which include the following:
   a. Architectural floor plans indicating all system device locations.
   b. Full schematic wiring information for all devices. Wiring information shall include cable type, cable length, conductor routings, quantities, and point-to-point termination schedules.
   c. Complete system one-line block diagram.
   d. Statement of the system sequence of operation.
   e. Riser diagrams showing interconnections.
   f. Detail drawings showing installation and mounting.
   g. Calculations detailing 25% spare capacity of each circuit.

2. All drawings shall be fully dimensioned.
3. Operating License: Submit evidence of application for FCC Radio Station Authorization prior to installing equipment. Furnish the license or a copy of the application for the license, to the Owner/End User prior to operating the equipment. The original license must be delivered to the Owner/End User.

C. As-Built Drawings

1. At the conclusion of the project, the Contractor shall provide “as built” drawings. The “as built” drawings shall be a continuation of the Contractors shop drawings as modified, augmented, and reviewed during the installation, check out and acceptance phases of the project. All drawings shall be fully dimensioned and prepared in DWG format using the latest version of AutoCAD.
2. The as-built drawings shall incorporate all updated system riser diagrams prepared in DWG format using the latest version of AutoCAD.

D. Manuals

1. At the conclusion of the project, the Contractor shall provide copies of the manuals as described herein. Each manual’s contents shall be identified on the cover. The manual shall include names, addresses, and telephone numbers of each system integrator installing equipment and systems and the nearest service representatives for each item of equipment for each system. The manuals shall have a table of contents and labeled sections. The manuals shall include all modifications made during installation, checkout, and acceptance. The manuals shall contain the following:
   a. Functional Design Manual
      1) The functional design manual shall identify the operational requirements for the system and explain the theory of operation, design philosophy, and specific functions. A description of hardware and software functions, interfaces, and requirements shall be included for all system operating modes.
   b. Hardware Manual
      1) The hardware manual shall describe all equipment furnished including:
         a) General description and specifications
         b) Installation and check out procedures
         c) Equipment layout and electrical schematics to the component level
         d) System layout drawings and schematics
         e) Alignment and calibration procedures
         f) Manufacturers repair parts list indicating sources of supply
   c. Software Manual
      1) The software manual shall describe the functions of all software and shall include all other information necessary to enable proper loading, testing, and operation. The manual shall include:
         a) Definition of terms and functions
         b) Use of system and applications software
         c) Initialization, start up, and shut down
         d) Alarm reports
         e) Reports generation
         f) Data base format and data entry requirements
         g) Directory of all disk files

2. Operators Manual
   a. The operator’s manual shall fully explain all procedures and instructions for the operation of the system including:

1) Computers and peripherals
2) System start up and shut down procedures
3) Use of system, command, and applications software
4) Recovery and restart procedures
5) Graphic alarm presentation
6) Use of report generator and generation of reports
7) Data entry
8) Operator commands
9) Alarm messages and reprinting formats
10) System access requirements

3. Maintenance Manual
   a. The maintenance manual shall include descriptions of maintenance for all equipment including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective components.

1.9 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings and Cabling Administration Drawings, and field testing program development by an RCDD.
2. Installation Supervision: Installation shall be under the direct supervision of Registered Technician, who shall be present at all times when Work of this Section is performed at Project site.
3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

C. Telecommunications Pathways and Spaces: Comply with TIA-569.

D. Grounding: Comply with ANSI-J-STD-607.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.

1. Test optical fiber cable to determine the continuity of the strand end to end. Use optical loss test set.
2. Test optical fiber cable while on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector, including the loss value of each. Retain test data and include the record in maintenance data.
3. Test each pair of UTP cable for open and short circuits.

1.11 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.12 COORDINATION

A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

B. The ceiling cavity is being used as plenum return. Provide plenum rated cables, conduit, backboxes in all plenum rated ceilings, rated walls, penetrations though wall, floors and ceilings and where required by Local, State or Federal Codes.

1.13 QUALIFICATION OF SYSTEM

A. Acceptable proposed systems will be covered by a two-part certification program provided by a single manufacturer and that manufacturer's certified Contractor. Manufacturer shall administer a follow on program through the Contractor to provide support and service to the purchaser. The first part is an assurance program, which provides that the certified system will support the applications for which it is designed, during the life time warranty of the certified system.

B. The second portion of the certification is a life time warranty provided by the manufacturer and the vendor on all products within the system (cords, telecommunications outlet/connectors, cables, cross-connects, patch panels, etc.).

C. In the event that the certified system ceases to support the certified application(s), whether at the time of cutover, during normal use or when upgrading (e.g. ATM), the manufacturer and Contractor shall commit to promptly implement corrective action.

D. Documentation proving the cabling system's compliance to the End-to-End Link Performance recommendations, as listed in TIA-568 shall be provided by the Contractor prior to the structured cabling system being installed.

E. The cabling system must conform to the current issue of industry standard TIA-568. All performance requirements of this document must be followed. As well, workmanship and installation methods used shall be equal to or better than that found in the BICSI (Building Industry Consulting Service International) TDMM manual.

F. The Owner demands strict adherence to the performance specifications listed in TIA-568 series standards.

G. Manufacturer shall maintain ISO Quality Control registration for the facilities that manufacturer the product used in this cabling system.

1.14 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 UTP CABLE

A. Approved Manufacturers

1. Berk-Tek.
2. General Cable.
3. Panduit.
4. Or approved equal.

B. Basis of Design

1. The system specified is based upon products by Berk-Tek and represents the performance standard upon which any equivalent solution shall be based.

C. Description: 100-ohm, 4-pair UTP, formed into 25-pair binder groups covered with a blue thermoplastic jacket.

1. Comply with ICEA S-90-661 for mechanical properties.
2. Comply with TIA-568 for performance specifications.
3. Comply with TIA-568, Category 5e, Category 6 and Category 6A.
4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:
   a. Communications, General Purpose: Type CM or CMG.
   b. Communications, Plenum Rated: Type CMP, complying with NFPA 262.
   c. Communications, Riser Rated: Type CMR, complying with UL 1666.
   d. Communications, Limited Purpose: Type CMX.
   e. Multipurpose: Type MP or MPG.
   f. Multipurpose, Plenum Rated: Type MPP, complying with NFPA 262.
   g. Multipurpose, Riser Rated: Type MPR, complying with UL 1666.

5. Basis of design recommendations:
   a. Voice/Data: Category 6 – Outdoor (10139885).

6. Category 3 high pair count: Superior Essex
7. 25-Pair plenum: 18-499-33
8. 50-Pair plenum: 18-599-33
9. 100-Pair plenum: 18-789-33
10. 200-Pair plenum: 18-A99-33
11. 300-Pair plenum: 18-B99-33

2.2 UTP HARDWARE

A. Basis of design recommendations

1. Leviton 41AB2-1F4 100-Pair 110-punchdown block kit.

2.3 NETWORK PROTECTION

A. Approved Manufacturers

1. Porta Systems Corp.
2. Circa Telecom.
3. EDCO.
4. Or approved equal.

B. Basis of design

1. The system specified is based upon products by Porta Systems Corp. and represents the performance standard upon which any equivalent solution shall be based.

C. Provide lighting protection for all copper lines entering each building.

D. Design recommendations (Porta Systems Corp.):

1. 24100-110-F110P 100-pair building entrance termination with solid state protectors.

2.4 OPTICAL FIBER CABLE

A. Approved Manufacturers

1. Berk-Tek.
2. Mohawk.
3. General Cable.
4. Or approved equal.

B. Basis of Design

1. The system specified is based upon products by Berk-Tek and represents the performance standard upon which any equivalent solution shall be based.

C. Description: Multimode, 50/125-micrometer, laser optimized, optical fiber cable.

1. Comply with ICEA S-83-596 for mechanical properties.
2. Comply with TIA-568 for performance specifications.
3. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
   a. General Purpose, Nonconductive: Type OFN or OFNG.
   b. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
   c. Riser Rated, Nonconductive: Type OFNR, complying with UL 1666.
   d. General Purpose, Conductive: Type OFC or OFCG.
   e. Plenum Rated, Conductive: Type OFCP, complying with NFPA 262.
   f. Riser Rated, Conductive: Type OFCR, complying with UL 1666.
4. Maximum Attenuation: 3.50 dB/km at 850 nm; 1.5 dB/km at 1300 nm.
5. Minimum Modal Bandwidth: 160 MHz-km at 850 nm; 500 MHz-km at 1300 nm.
6. Multimode fiber shall be terminated in type SC connectors (verify with Owner).

D. Description: Single mode, 8.3/125- micrometer, optical fiber cable.

1. Comply with ICEA S-83-596 for mechanical properties.
2. Comply with TIA-568 for performance specifications.
3. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
   a. General Purpose, Nonconductive: Type OFN or OFNG.
   b. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262.
   c. Riser Rated, Nonconductive: Type OFNR, complying with UL 1666.
   d. General Purpose, Conductive: Type OFC or OFCG.
   e. Plenum Rated, Conductive: Type OFCP, complying with NFPA 262.
   f. Riser Rated, Conductive: Type OFCR, complying with UL 1666.

4. Single mode fiber shall be terminated in type SC connectors (verify with Owner).

E. Jacket:

1. Jacket Color: Aqua for 50/125-micrometer cable; Orange for 62.5/125-micrometer cable and Yellow for single mode fiber.
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598.
3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

F. Design recommendations:

1. Multi-Mode fiber - for data backbone system infrastructure, multi-mode 50/125-micron, OM4 laser optimized, indoor/outdoor rated, manufactured by Leviton,
   a. 6-Strand: P/N PDPK006FB3010/F5-I/O-C4C5(AQU) OM4 armored.
   b. 12-Stand: P/N PDPK012FB3010/F5-I/O-C4C5(AQU) OM4 armored.
   c. 24-Strand: P/N PDPK024FB3010/F5-I/O-C4C5(AQU) OM4 armored.
   d. 50/125 multimode fiber shall be terminated with LC style connectors.

2. Single-Mode Fiber, indoor/outdoor rated, manufactured by Leviton,
   a. 6-Strand: P/N PDPK006AB0707-I/O-C4C5(YEL) armored.
   b. 12-Strand: P/N PDPK012AB0707-I/O-C4C5(YEL) armored.
   c. 24-Strand: P/N PDPK024AB0707-I/O-C4C5(YEL) armored.
   d. 8.3/125 single-mode fiber shall be terminated with LC style connectors.

2.5 OPTICAL FIBER CABLE HARDWARE

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. Leviton.
2. Panduit.
3. Hubbell.
4. Or approved equal.

B. Basis of Design

1. The system specified is based upon products by Leviton and represents the performance standard upon which any equivalent solution shall be based.

C. Cable Connecting Hardware: Meet the Optical Fiber Connector Intermateability Standards (FOCIS) specifications of TIA-604. Comply with TIA-568.

1. Quick-connect, simplex and duplex, Type SC connectors. Insertion loss not more than 0.75 dB.
2. Type SFF connectors may be used in termination racks, panels, and equipment packages.

D. Basis of design recommendations:

1. Leviton 5R2UM-F06, rack mount distribution enclosure, 2RU.
2. Leviton 5F100-2LL single mode 12-strands with LC connectors.
3. Leviton 5F100-2QL multimode 50 Micron 12-strands with LC connectors.
4. Leviton 5F100-2IL multimode 62.5 Micron 12-strands with LC connectors.

E. Patch Cords: Provide patch cords for all fiber ports in each telecommunications closet.

1. Leviton UPDLC-SXX, LC-LC single mode patch cord.
2. Leviton 54DLC-MXX, laser optimized OM4 duplex, LC-LC 50 Micron multimode patch cord.
3. Provide patch cord for each port, minimum length shall one 1 meter. Coordinate exact lengths with the Owner.

2.6 GROUNDING

A. Comply with requirements in Division 26.

B. Comply with ANSI-J-STD-607-A.

2.7 IDENTIFICATION PRODUCTS

A. Comply with TIA-606 and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.8 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Factory test cables on reels according to TIA-568.

C. Factory test UTP cables according to TIA-568.

D. Factory test multimode optical fiber cables according to TIA-526 and TIA-568.

E. Cable will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 ENTRANCE FACILITIES

A. Coordinate backbone cabling with the protectors and demarcation point provided by communications service provider.

B. Provide lightning protection for all copper backbone cables entering or leaving a telecommunications closet/room.

3.2 WIRING METHODS

A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces, in attics, and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.

2. Comply with requirements for raceways and boxes specified in Division 26.

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.3 INSTALLATION OF PATHWAYS

A. Cable Trays: Comply with NEMA VE 2 and TIA-569.

B. Comply with requirements for demarcation point, pathways, cabinets, and racks specified in Division 27. Drawings indicate general arrangement of pathways and fittings.

C. Comply with TIA-569 for pull-box sizing and length of conduit and number of bends between pull points.

D. Comply with requirements in Division 26 for installation of conduits, wireways and raceways.

E. Install manufactured conduit sweeps and long-radius elbows whenever possible.

F. Pathway Installation in Communications Equipment Rooms:

1. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed, or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.
2. Install cable trays to route cables if conduits cannot be located in these positions.
3. Secure conduits to backboard when entering room from overhead.
4. Extend conduits 3 inches (76 mm above finished floor.
5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

G. Backboards: Install backboards with 96-inch (2440-mm) dimension vertical. Butt adjacent sheets tightly, and form smooth gap-free corners and joints.

3.4 INSTALLATION OF CABLES

A. Comply with NECA 1.

B. General Requirements for Cabling:

1. Comply with TIA-568.
2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
3. Install IDC termination hardware unless otherwise indicated.
4. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
5. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
6. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.

7. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Use lacing bars and distribution spools.
8. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
9. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
10. In the communications equipment room, install a 10-foot- (3-m-) long service loop on each end of cable.
11. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

C. UTP Cable Installation:

1. Comply with TIA-568.
2. Do not untwist UTP cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.

D. Optical Fiber Cable Installation:

1. Comply with TIA-568.
2. Cable may be terminated on connecting hardware that is rack or cabinet mounted.

E. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend UTP cable not in a wireway or pathway, a minimum of 8 inches (200 mm) above ceilings by cable supports not more than 60 inches (1524 mm) apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

F. Installation of Cable Routed Exposed under Raised Floors:

1. Install plenum-rated cable only.
2. Install cabling after the flooring system has been installed in raised floor areas.
3. Coil cable 6 feet (1800 mm) long not less than 12 inches (300 mm) in diameter below each feed point.

G. Group connecting hardware for cables into separate logical fields.

H. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA-569 recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (610 mm).

3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).

4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (76 mm).
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).

5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

3.5 TESTING, IDENTIFICATION AND ADMINISTRATION

A. Comply with Section 27 17 10 and Section 27 17 20 for testing, identification and administration of the backbone cabling infrastructure.

3.6 FIRESTOPPING

A. Installed by Electrical Subcontractor, refer to 07 84 13 for products and installation requirements

B. Comply with TIA-569, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.7 GROUNDING

A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. Comply with ANSI-J-STD-607-A.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch (50-mm) clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.

D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.8 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup checks according to the approved manufacturer's written instructions.

3.9 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct two 4-hour training sessions. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

End of Section

Section 27 15 00

COMMUNICATIONS HORIZONTAL CABLING

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. Section Includes:

1. Pathways.
2. UTP cabling.
3. 50/125-micrometer, optical fiber cabling.
4. Single mode optical fiber cabling.
5. Cable connecting hardware, patch panels, and cross-connects.
6. Telecommunications outlet/connectors.
7. Cabling system identification products.
8. Cable management system.

B. Related Sections:

1. Division 27 for voice and data cabling associated with system panels and devices.
2. Division 27 for low voltage cabling.

1.4 DEFINITIONS

A. Basket Cable Tray: A fabricated structure consisting of wire mesh bottom and side rails.

B. BICSI: Building Industry Consulting Service International.

C. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.

D. EMI: Electromagnetic interference.

E. IDC: Insulation displacement connector.

F. Ladder Cable Tray: A fabricated structure consisting of two longitudinal side rails connected by individual transverse members (rungs).

G. LAN: Local area network.

H. Outlet/Connectors: A connecting device in the work area on which horizontal cable or outlet cable terminates.

I. RCDD: Registered Communications Distribution Designer.

J. UTP: Unshielded twisted pair.

1.5 CODES AND STANDARDS

A. Complete installation shall meet or exceed the latest edition of following standards:

1. TIA-568: Commercial building telecommunications wiring standard and all current addenda.
2. TIA-569: Commercial building standard for telecommunications pathways and spaces.
3. TIA-606: Administration standard for telecommunications infrastructure of commercial buildings.
4. TIA-607: Commercial building grounding and bonding requirements for telecommunications.
5. ANSI, ASTM, UL, NEMA, IEEE and FCC standards as applicable.
6. BICSI Telecommunications Distribution Methods Manual, current edition.

1.6 HORIZONTAL CABLING DESCRIPTION

A. Horizontal cable and its connecting hardware provide the means of transporting signals between the telecommunications outlet/connector and the horizontal cross-connect located in the telecommunications closet/room. This cabling and its connecting hardware are called "permanent link," a term that is used in the testing protocols.

1. Horizontal cabling shall contain no more that one transition point or consolidation point between the horizontal cross-connect and the telecommunications outlet/connector.
2. Bridged taps and splices shall not be installed in the horizontal cabling.
3. Splitters shall not be installed as part of the optical fiber cabling.

B. A work area is approximately 100 sq. ft. (9.3 sq. m), and includes the components that extend from the telecommunications outlet/connectors to the station equipment.

C. The maximum allowable horizontal cable length is 295 feet (90 m). This maximum allowable length does not include an allowance for the length of 16 feet (4.9 m) to the workstation equipment. The maximum allowable length does not include an allowance for the length of 16 feet (4.9 m) in the horizontal cross-connect.

1.7 PERFORMANCE REQUIREMENTS

A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA-568, when tested according to test procedures of this standard.

1.8 SUBMITTALS

1. Comply with requirements in Division 01.

B. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

1. Layout Responsibility: Preparation of Shop Drawings and Cabling Administration Drawings, and field testing program development by an RCDD.
2. Installation Supervision: Installation shall be under the direct supervision of Registered Technician, who shall be present at all times when Work of this Section is performed at Project site.
3. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

D. Telecommunications Pathways and Spaces: Comply with TIA-569.

E. Grounding: Comply with ANSI-J-STD-607.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.

1. Test optical fiber cable to determine the continuity of the strand end to end. Use optical loss test set.
2. Test optical fiber cables while on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector; including the loss value of each. Retain test data and include the record in maintenance data.
3. Test each pair of UTP cable for open and short circuits.

1.10 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.11 COORDINATION

A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

B. Coordinate telecommunications outlet/connector locations with location of power receptacles at each work area.

C. It is this Electrical Subcontractor’s responsibility to refer to Architectural and Mechanical drawings and/or conduct a physical walk thru at the site to determine the plenum rating of all the ceilings. Provide plenum rated cables, conduit, backboxes in all plenum rated ceilings, rated walls, penetrations though wall, floors and ceilings and where required by Local, State or Federal Codes.

1.12 QUALIFICATION OF SYSTEM

A. Acceptable proposed systems will be covered by a two-part certification program provided by a single manufacturer and that manufacturer's certified Subcontractor. Manufacturer shall administer a follow-on program through the Subcontractor to provide support and service to the purchaser. The first part is an assurance program, which provides that the certified system will support the applications for which it is designed, during the life time warranty of the certified system.

B. The second portion of the certification is a life time warranty provided by the manufacturer and the vendor on all products within the system (cords, telecommunications outlet/connectors, cables, cross-connects, patch panels, etc.).

C. In the event that the certified system ceases to support the certified application(s), whether at the time of cutover, during normal use or when upgrading (e.g. ATM), the manufacturer and Subcontractor shall commit to promptly implement corrective action.

D. Documentation proving the cabling system's compliance to the End-to-End Link Performance recommendations, as listed in ANSITIA-568 shall be provided by the Subcontractor prior to the structured cabling system being installed.

E. The cabling system must conform to the current issue of industry standard TIA-568. All performance requirements of this document must be followed. As well, workmanship and installation methods used shall be equal to or better than that found in the BICSI (Building Industry Consulting Service International) TDMM manual.

F. The Owner demands strict adherence to the performance specifications listed in TIA-568 series standards.

G. Manufacturer shall maintain ISO Quality Control registration for the facilities that manufacturer the product used in this cabling system.

1.13 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 UTP CABLE

A. Approved Manufacturers

1. Berk-Tek
2. General Cable
3. Mohawk
4. Or approved equal.

B. Basis of design based upon products by Berk-Tek.

C. Description: 100-ohm, 4-pair UTP, formed into 25-pair binder groups covered with a blue thermoplastic jacket.

1. Comply with ICEA S-90-661.
2. Comply with TIA-568-B.1.
3. Comply with TIA-568-B.2.
4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:
   a. Communications, General Purpose: Type CM or CMG.
   b. Communications, Plenum Rated: Type CMP, complying with NFPA 262.
   c. Communications, Riser Rated: Type CMR, complying with UL 1666.
   d. Communications, Limited Purpose: Type CMX.
   e. Multipurpose: Type MP or MPG.
   f. Multipurpose, Plenum Rated: Type MPP, complying with NFPA 262.
   g. Multipurpose, Riser Rated: Type MPR, complying with UL 1666.

D. Design recommendations:

1. Voice/Data: Category 6A Plenum Rated Cable
   a. Indoor:
      1) Blue (Data): Berk-Tek 10130484 LANmark-10G2
      2) White (VoIP): Berk-Tek 10137384 LANmark-10G2
      3) Yellow (Security): Berk-Tek 10137385 LANmark-10G2
      4) Grey (Fax/Analog): Berk-Tek 11096831 LANmark-10G2
      5) Violet (Clock/PA): Berk-Tek 10140145 LANmark-10G2
      6) Green (WAP): Berk-Tek 10137694 LANmark-10G2
      7) Pink (FCHW): Berk-Tek 10138181 LANmark-10G2
   b. Outdoor:
      1) Berk-Tek 10139885. LANmark6 Cat 6.
   c. Category 3 high pair count: General Cable.
      1) 25-Pair plenum 2131505
      2) 50-Pair plenum 2131757
      3) 100-Pair plenum 2131758
      4) 200-Pair plenum 2131442
      5) 300-Pair plenum 2131474

2. Non-plenum rated cables shall not be acceptable.

2.2 UTP CABLE HARDWARE

A. Approved Manufacturers

1. Leviton.
2. Panduit Corp.
3. Hubbell.
4. Or approved equal.

B. Basis of design based upon products by Leviton.

C. UTP Cable Connecting Hardware: Tool-free type, using Component Rated Category 6A modules.

D. Shielded Cable Connecting Hardware: Must be Component Rated Category 6A.

E. Connecting Blocks: Punch down style for Category 6A. Provide blocks for the number of cables terminated on the block, plus 25 percent spare. Integral with connector bodies, including plugs and jacks where indicated.

F. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.

G. Number of Terminals per Field: One for each conductor in assigned cables.

H. Patch Panel: Component Rated Category 6A 110 style panels to include a rear cable management/strain relief bracket.

I. Number of Jacks per Field: One for each four-pair UTP cable indicated.

J. Jacks and Jack Assemblies: Tool-free, color-coded, eight-position modular receptacle units using Component Rated Category 6A modules.

K. Patch Cords: Factory-made by the connecting hardware manufacturer, four-pair cables in 60-inch (900 mm) lengths; terminated with eight-position modular plug at each end.

L. UTP patch cords shall be color-coded. Patch cords shall have a snagless design.

M. UTP patch cords shall have transparent slimline boots and be color-coded for circuit identification.

N. Provide patch cord for each workstation outlet and each port in the telecommunications rooms.

O. Basis of design recommendations (Leviton).

1. Wall Plates:
    a. 43080-1S1 - 1 port stainless steel faceplate
    b. 43080-1S2 - 2 port stainless steel faceplate
    c. 43080-1S3 - 3 port stainless steel faceplate
    d. 43080-1S4 - 4 port stainless steel faceplate
    e. 4108W-1SP - wall phone faceplate

2. 41AB2-1F4 100-Pair 110-punchdown block kit.
3. Category 6A Component Rated jack modules
    a. 6AUJK-S*6 UTP Connectors with metal body and internal shutters
        1) * = L – Blue (Data)
        2) * = Y – yellow (Security)
        3) * = W – White (VoIP)
        4) * = G – Grey (Fax)
        5) * = P – Purple (Clock/PA)
        6) * = V – Green (WAP)
        7) * = C – Crimson (FCHW)
    b. Provide icons to match jack modules.
    c. Jack modules with field installed shutters shall not be acceptable.

4. 41084-FWF F - connector modules
5. 6AS10-xx* (coordinate with owner on lengths-xx) Category 6A Component Rated patch cord

a. UTP patch cord color coding:
   1) Data: Blue. (L)
   2) Security: Yellow (Y)
   3) Voice: White. (W)
   4) Fax: Grey (G)
   5) Clock/PA: Purple (P)
   6) Wireless Access Points (WAP): Green (V)
   7) FCHW: Crimson (C)
b. UTP patch cord lengths:
   1) 25% 3 ft.
   2) 25% 5 ft.
   3) 50% 7 ft.

6. 6A587-U48 CAT 6A 48-port modular angled jack panel
   a. Arrange patch panels to allow for mounting of the chassis switch in between the patch panels rather than mounting the switch on the bottom of the rack or in a separate.
   b. Coordinate rack layout with Worcester Public Schools (WPS) IT department.

7. 4980L-VFR – vertical cable management panel (front and rear)

2.3 GROUNDING

A. Comply with requirements in Division 26.

B. Comply with ANSI-J-STD-607-A.

2.4 IDENTIFICATION PRODUCTS

A. Comply with TIA-606 and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.5 LABELING

A. When labeling Jacks and Panels you will follow this example: “room number – port in room” i.e. 123-1, 123-2, 123-3 and so on. When labeling Wireless Access Points, the word “WAP” will be labeled on the line above the jack number. This allows IT department to track issues from the closets to the classrooms without needing to go through each room to track down were a drop is.

B. Coordinate labeling with the IT department.

C. Coordinate and obtain a written approval of room names and numbers from the Architect prior to labeling the ports.

D. All patch panel and station terminations are to be electronically labeled with a P-touch or similar device, no handwritten labeling is accepted.

2.6 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Factory test cables on reels according to TIA-568.

C. Factory test UTP cables according to TIA-568.

D. Factory test multimode optical fiber cables according to TIA-526 and TIA-568.

E. Cable will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

PART 3 - EXECUTION

3.1 ENTRANCE FACILITIES

A. Coordinate backbone cabling with the protectors and demarcation point provided by communications service provider.

3.2 WIRING METHODS

A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces, in attics, and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for raceways and boxes specified in Division 26.

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.3 INSTALLATION OF PATHWAYS

A. Cable Trays: Comply with NEMA VE 2 and TIA-569.

B. Comply with requirements for demarcation point, pathways, cabinets, and racks specified in Division 27. Drawings indicate general arrangement of pathways and fittings.

C. Comply with TIA-569 for pull-box sizing and length of conduit and number of bends between pull points.

D. Comply with requirements in Division 26 for installation of conduits, raceways and wireways.

E. Install manufactured conduit sweeps and long-radius elbows whenever possible.

F. Pathway Installation in Communications Equipment Rooms:

1. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed, or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.
2. Install cable trays to route cables if conduits cannot be located in these positions.
3. Secure conduits to backboard when entering room from overhead.
4. Extend conduits 3 inches (76 mm above finished floor.
5. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

G. Backboards: Install backboards with 96-inch (2440-mm) dimension vertical. Butt adjacent sheets tightly, and form smooth gap-free corners and joints.

3.4 TELECOMMUNICATIONS OUTLET/CONNECTORS

A. Jacks: 100-ohm, balanced, twisted-pair connector; four-pair, eight-position modular. Comply with TIA-568.

B. Workstation Outlets: Two-port-connector assemblies mounted in single faceplate unless otherwise noted.

1. Plastic Faceplate: High-impact plastic. Coordinate color with Division 26.
2. Metal Faceplate: Stainless steel, complying with requirements in Division 26.
3. Faceplates will allow snap-in jacks accommodating any combination of UTP, optical fiber, and coaxial work area cords.
4. Labeling: Machine printed, in the field, using adhesive-tape label or snap-in, clear-label covers and machine-printed paper inserts.

3.5 CABLE MANAGEMENT SYSTEM

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:

1. Panduit
2. iTRACS Corporation.
3. Telsoft Solutions.
4. Or approved equal.

C. Description: Computer-based cable management system, with integrated database and graphic capabilities.

D. Document physical characteristics by recording the network, TIA details, and connections between equipment and cable.

E. Information shall be presented in database view, schematic plans, and technical drawings.

1. AutoCAD drawing software shall be used as drawing and schematic plans software.

F. System shall interface with the following testing and recording devices:

1. Direct upload tests from circuit testing instrument into the personal computer.
2. Direct download circuit labeling into labeling printer.

3.6 SOURCE QUALITY CONTROL

A. Factory test UTP and optical fiber cables on reels according to TIA-568.

B. Factory test UTP cables according to TIA-568.

C. Factory test multimode optical fiber cables according to TIA-526 and TIA-568.

D. Cable will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

3.7 INSTALLATION OF CABLES

A. Comply with NECA 1.

B. General Requirements for Cabling:

1. Comply with TIA-568.
2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
3. Install 110-style IDC termination hardware unless otherwise indicated.
4. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
5. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
6. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
7. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
8. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
9. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
10. In the communications equipment room, install a 10-foot- (3-m-) long service loop on each end of cable.
11. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

C. UTP Cable Installation:

1. Comply with TIA-568.
2. Do not untwist UTP cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.

D. Optical Fiber Cable Installation:

1. Comply with TIA-568.
2. Cable may be terminated on connecting hardware that is rack or cabinet mounted.

E. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend UTP cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceilings by cable supports not more than 60 inches (1524 mm) apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

F. Installation of Wireless (Wi-Fi) Access Point (AP) Cabling:

1. Direct Mounting to the Ceiling Grid: In an area where there is a drop ceiling, the cabling for the AP shall be terminated above the ceiling but not higher than 10 ft. above the floor. Mark the location with a green dot sticker on the ceiling directly under the terminated jacks.
2. Right Angle Bracket Mounting (Access Point mounting on a wall): In an area where the AP is scheduled to be mounted on the wall, terminate AP cabling on a standard 2-port faceplate on the wall. Coordinate exact height in the field.
3. Open Ceiling Mounting: In an area where the AP is scheduled to be mounted in open ceiling location, the cabling for the AP shall be terminated on a standard 2-port faceplate which shall be located in a 4” square junction box. This junction box shall be mounted to a rigid steel 1” conduit that is secured to another 4” square junction box mounted to the building structure above. The patch cord shall then be run through the 1” rigid steel conduit to second 4” square junction box with cover. The Contractor will need to punch a hole through the second box cover allowing the AP cables to pass through.

G. Installation of Cable Routed Exposed under Raised Floors:

1. Install plenum-rated cable only.
2. Install cabling after the flooring system has been installed in raised floor areas.
3. Coil cable 6 feet (1800 mm) long not less than 12 inches (300 mm) in diameter below each feed point.
4. Group connecting hardware for cables into separate logical fields.

H. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA-569 for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (610 mm).

3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).

c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).

4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
   a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
   b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (76 mm).
   c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).

5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

3.8 FIRESTOPPING

A. Installed by Electrical Subcontractor, refer to 07 84 13 for products and installation requirements

B. Comply with TIA-569, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.9 GROUNDING

A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. Comply with ANSI-J-STD-607-A.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch (50-mm) clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.

D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.10 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA-606. Comply with requirements for identification specified in Division 26.

1. Administration Class: 4.
2. Color-code cross-connect fields. Apply colors to voice and data service backboards, connections, covers, and labels.

B. Using cable management system software specified in Part 2, develop Cabling Administration Drawings for system identification, testing, and management. Use unique, alphanumeric designation for each cable and label cable, jacks, connectors, and terminals to which it connects with same designation. At completion, cable and asset management software shall reflect as-built conditions.

C. Comply with requirements in Division 09 for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.

D. Paint and label colors for equipment identification shall comply with TIA-606 for Class 4 level of administration.

E. Cable Schedule: Post in prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

F. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, backbone pathways and cables, entrance pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors. Follow convention of TIA-606. Furnish electronic record of all drawings, in software and format selected by Owner.

G. Cable and Wire Identification:

1. Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet (4.5 m).
4. Label each terminal strip and screw terminal in each cabinet, rack, or panel.
    a. Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with name and number of particular device as shown.
    b. Label each unit and field within distribution racks and frames.

5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.

H. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA-606.

1. Cables use flexible vinyl or polyester that flex as cables are bent.

3.11 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Visually inspect UTP and optical fiber cable jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA-568.
2. Visually confirm Category 6 marking of outlets, cover plates, outlet/connectors, and patch panels.

3. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
4. Test UTP backbone copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.
    a. Test instruments shall meet or exceed applicable requirements in TIA-568. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.

5. Optical Fiber Cable Tests:
    a. Test instruments shall meet or exceed applicable requirements in TIA-568. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
    b. Link End-to-End Attenuation Tests:
        1) Horizontal and multimode backbone link measurements: Test at 850 or 1300 nm in 1 direction according to TIA-526, Method B, One Reference Jumper.
        2) Attenuation test results for backbone links shall be less than 2.0 dB. Attenuation test results shall be less than that calculated according to equation in TIA-568.

6. UTP Performance Tests:
    a. Test for each outlet and MUTOA. Perform the following tests according to TIA-568 and TIA-568:
        1) Wire map.
        2) Length (physical vs. electrical, and length requirements).
        3) Insertion loss.
        4) Near-end crosstalk (NEXT) loss.
        5) Power sum near-end crosstalk (PSNEXT) loss.
        6) Equal-level far-end crosstalk (ELFEXT).
        7) Power sum equal-level far-end crosstalk (PSELFEXT).
        8) Return loss.
        9) Propagation delay.
        10) Delay skew.

7. Optical Fiber Cable Performance Tests: Perform optical fiber end-to-end link tests according to TIA-568 and TIA-568.
8. Final Verification Tests: Perform verification tests for UTP and optical fiber systems after the complete communications cabling and workstation outlet/connectors are installed.
    a. Voice Tests: These tests assume that dial tone service has been installed. Connect to the network interface device at the demarcation point. Go off-hook and listen and receive a dial tone. If a test number is available, make and receive a local, long distance, and digital subscription line telephone call.
    b. Data Tests: These tests assume the Information Technology Staff has a network installed and is available to assist with testing. Connect to the network interface device at the demarcation point. Log onto the network to ensure proper connection to the network.

B. Document data for each measurement. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.

C. End-to-end cabling will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

3.12 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup checks according to the approved manufacturer's written instructions.

3.13 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct two 4-hour training sessions. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

End of Section

Section 27 17 10

TESTING OF FIBER INFRASTRUCTURE

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. Provide all labor, materials, tools, field-test instruments and equipment required for the complete testing, identification and administration of the work called for in the Contract Documents.

B. In order to conform to the overall project event schedule, the Cabling Trade Contractor shall survey the work areas and coordinate cabling testing with other applicable trades.

C. In addition to the tests detailed in this document, the Contractor shall notify the Owner or the Owner’s representative of any additional tests that are deemed necessary to guarantee a fully functional system. The Contractor shall carry out and record any additional measurement results at no additional charge.

D. This Section includes the minimum requirements for the test certification, identification and administration of backbone and horizontal optical fiber cabling.

E. This Section includes minimum requirements for:

1. Fiber optic test instruments
2. Fiber optic testing
3. Identification
    a. Labels and labeling

4. Administration
    a. Test results documentation
    b. As-built drawings

F. Testing shall be carried out in accordance with this document. This includes testing the attenuation and polarity of the installed cable plant with an optical loss test set (OLTS) and the installed condition of the cabling system and its components with an optical time domain reflectometer (OTDR). The condition of the fiber end faces shall also be verified.

G. Testing shall be performed on each cabling link (connector to connector).

H. Testing shall be performed on each cabling channel (equipment to equipment) that is identified by the owner.

1. Testing shall not include any active devices or passive devices within the link or channel other than cable, connectors, and splices, i.e. link attenuation does not include such devices as optical bypass switches, couplers, repeaters, or optical amplifiers.

I. All tests shall be documented including OLTS dual wavelength attenuation measurements for multimode and single mode links and channels and OTDR traces and event tables for multimode and single mode links and channels.

1.4 QUALITY ASSURANCE

A. All testing procedures and field-test instruments shall comply with applicable requirements of:

1. ANSI Z136.2, ANS For Safe Use Of Optical Fiber Communication Systems Utilizing Laser Diode And LED Sources
2. ANSI/EIA/TIA-455-50B, Light Launch Conditions For Long-Length Graded-Index Optical Fiber Spectral Attenuation Measurements
3. ANSI/TIA/EIA-455-59A, Measurement of Fiber Point Discontinuities Using an OTDR
4. ANSI/TIA/EIA-455-60A, Measurement of Fiber or Cable Length Using an OTDR
5. ANSI/TIA/EIA-455-61A, Measurement of Fiber or Cable Attenuation Using an OTDR
6. ANSI/TIA/EIA-526-7, Optical Power Loss Measurements of Installed Singlemode Fiber Cable Plant
7. ANSI/TIA-526-14-B, Optical Power Loss Measurements of Installed Multimode Fiber Cable Plant; IEC 61280-4-1 edition 2, Fibre-Optic Communications Subsystem Test Procedure- Part 4-1: Installed cable plant- Multimode attenuation measurement
8. ANSI/TIA-568-C.0, Generic Telecommunications Cabling for Customer Premises
9. ANSI/TIA-568-C.3, Optical Fiber Cabling Components Standard
10. ANSI/TIA-606-B, Administration Standard for Commercial Telecommunications Infrastructure, including the requirements specified by the customer, unless the customer specifies their own labeling requirements

B. Trained technicians who have successfully attended an appropriate training program, which includes testing with an OLTS and an OTDR and have obtained a certificate as proof thereof shall execute the tests. These certificates may have been issued by any of the following organizations or an equivalent organization:

1. Manufacturer of the fiber optic cable and/or the fiber optic connectors.
2. Manufacturer of the test equipment used for the field certification or representative.
3. Training organization e.g. BICSI

C. The Owner or the Owner’s representative shall be invited to witness and/or review field-testing.

1. The Owner or the Owner’s representative shall be notified of the start date of the testing phase five (5) business days before testing commences.

2. The Owner or the Owner's representative will select a random sample of 5% of the installed links. The Owner or the Owner's representative shall test these randomly selected links and the results are to be stored in accordance with Part 3 of this document. The results obtained shall be compared to the data provided by the installation Trade Contractor. If more than 2% of the sample results differ in terms of the pass/fail determination, the installation Trade Contractor under supervision of the representative shall repeat 100% testing at no cost to the Owner.

1.5 SUBMITTALS

A. Manufacturers catalog sheets and specifications for fiber optic field-test instruments including optical loss test sets (OLTS; power meter and source), optical time domain reflectometer (OTDR) and video microscope.

B. A schedule (list) of all optical fibers to be tested.

C. Sample test reports.

1.6 ACCEPTANCE OF TEST RESULTS

A. Unless otherwise specified by the Owner or the Owners representative, each cabling link shall be in compliance with the following test limits:

1. Optical loss testing
   a. Multimode and Single mode links
      1) The link attenuation shall be calculated by the following formulas as specified in ANSI/TIA-568-C.0.
         a) Link Attenuation (dB) = Cable_Attn (dB) + Connector_Attn (dB) + Splice_Attn (dB)
         b) Cable_Attn (dB) = Attenuation_Coefficient (dB/km) * Length (Km)
         c) Connector_Attn (dB) = number_of_connector_pairs * connector_loss (dB)
         d) Maximum allowable connector_loss = 0.75 dB
         e) Splice_Attn (dB) = number_of_splices * splice_loss (dB)
         f) Maximum allowable splice_loss = 0.3 dB
         g) The values for the Attenuation_Coefficient (dB/km) are listed in the table below:

Type of Optical Fiber	Wavelength (nm)	Attenuation Coefficient (dB/km)	Wavelength (nm)	Attenuation Coefficient (dB/km)
Multimode 62.5/125 µm	850	3.5	1300	1.5
Multimode 50/125 µm	850	3.5	1300	1.5
Single-mode (Inside plant)	1310	1.0	1550	1.0
Single-mode (Outside plant)	1310	0.5	1550	0.5

2. OTDR testing
   a. Reflective events (connections) shall not exceed 0.75 dB

b. Non-reflective events (splices) shall not exceed 0.3 dB.

3. Magnified end face inspection
   a. Fiber connections shall be visually inspected for end face quality.
   b. Scratched, pitted or dirty connectors shall be diagnosed and corrected.

B. All installed cabling links and channels shall be field-tested and pass the test requirements and analysis as described in Part 3. Any link or channel that fails these requirements shall be diagnosed and corrected. Any corrective action that must take place shall be documented and followed with a new test to prove that the corrected link or channel meets performance requirements. The final and passing result of the tests for all links and channels shall be provided in the test results documentation in accordance with Part 3.

C. Acceptance of the test results shall be given in writing after the project is fully completed and tested in accordance with Contract Documents and to the satisfaction of the Owner.

D. Note: High Bandwidth applications such as 1000BASE-SX, 10GBASE-SR, and FC1200 impose stringent channel loss limits. Where practical, certification should consider loss length limits that meet maximum channel (transmitter to receiver) loss. 0.75 dB per connector pair loss may not support the intended application.

E. Performance specification for multimode fiber links at 850 nm:

Fiber Type		Bandwidth	1000BASE-SX		10GBASE-SR		FibreChannel 1200-MX-SN-I	
	µm	(MHz• Km)	Length (m)	Loss (dB)	Length (m)	Loss (dB)	Length (m)	Loss (dB)
OM1	62.5	200	275	2.38	33	2.5	33	2.4
OM2	50	500	550	3.56	82	2.3	82	2.2
OM3	50	2000	N/A	N/A	300	2.6	300	2.6
OM4	50	47000	N/A	N/A	400	2.9	N/A	N/A

PART 2 - PRODUCTS

2.1 OPTICAL FIBER CABLE TESTERS

A. The field-test instrument shall be within the calibration period recommended by the manufacturer and a copy of the calibration certificate made available.

B. Optical loss test set (OLTS)

1. Multimode optical fiber light source
   a. Provide dual LED light sources with central wavelengths of 850 nm (±30 nm) and 1300 nm (±20 nm).
   b. Output power of –20 dBm minimum.
   c. The launch shall meet the Encircled Flux launch requirements of ANSI/TIA-526-14-B.

2. Single mode optical fiber light source
   a. Provide dual laser light sources with central wavelengths of 1310 nm (±20 nm) and 1550 nm (±20 nm).
   b. Output power of –10 dBm minimum.

3. Power Meter
   a. Provide 850 nm, 1300 nm, 1310 nm, and 1550 nm wavelength test capability.
   b. Power measurement uncertainty of ± 0.25 dB.
   c. Store reference power measurements.
   d. Save at least 10,000 results to internal memory.
   e. PC interface (USB).

C. Optical Time Domain Reflectometer (OTDR)

1. Shall have a bright, color LCD display with backlight.
2. Shall have rechargeable Li-Ion battery for 8 hours of normal operation.
3. Weight with battery and module of not more than 4.5 lb and volume of not more 200 in^3.
4. Internal non-volatile memory with capacity for storing at least 2,000 OTDR bi-directionally tested fiber links.
5. USB port to transfer data to a PC or thumb drive/memory stick.
6. Multimode OTDR
   a. Wavelengths of 850 nm (± 10 nm) and 1300 nm (+ 35 nm / - 15 nm).
   b. Event dead zones not to exceed 0.7 m at 850 nm and 1300 nm.
   c. Attenuation dead zones not to exceed 2.5 m at 850 nm and 4.5 m at 1300 nm.
   d. Distance range not less than 9,000 m.
   e. Dynamic range at least 28 dB for 850 nm and 30 dB at 1300 nm.

7. Single mode OTDR
   a. Wavelengths of 1310 nm (± 25 nm) and 1550 nm (± 30 nm).
   b. Event dead zones not to exceed 0.6 m at 1310 nm and 1550 nm.
   c. Attenuation dead zones not to exceed 3.7 m at 1310 nm and 1550 nm.
   d. Distance range not less than 80 km at 1310 nm and 130 km at 1550 nm.
   e. Dynamic range at least 32 dB for 1310 nm and 30 dB at 1550 nm.

D. Fiber Microscope

1. Magnification of 200X or 400X for end face inspection

E. Integrated OLTS, OTDR and fiber microscope

1. Test equipment that combines into one instrument an OLTS, an OTDR and a fiber microscope may be used.

2.2 IDENTIFICATION

A. Labels

1. Shall meet the legibility, defacement, exposure and adhesion requirements of UL 969.
2. Shall be preprinted using a mechanical means of printing (e.g., laser printer).
3. Where used for cable marking, provide vinyl substrate with a white printing area and a clear “tail” that self laminates the printed area when wrapped around the cable. If cable jacket is white, provide cable label with printing area that is any other color than white, preferably orange or yellow – so that the labels are easily distinguishable.

4. Where insert type labels are used provide clear plastic cover over label.
5. Provide plastic warning tape 6 inches wide continuously printed and bright colored 18" above all direct buried services, underground conduits and duct-banks.
6. Acceptable Manufacturers:
   a. Panduit
   b. Silver Fox
   c. W.H. Brady
   d. Or approved equal.

2.3 ADMINISTRATION

A. Administration of the documentation shall include test results of each fiber link and channel.

B. The test result information for each link shall be recorded in the memory of the field-test instrument upon completion of the test.

C. The test result records saved within the field-test instrument shall be transferred into a Windows™-based database utility that allows for the maintenance, inspection and archiving of these test records.

PART 3 - EXECUTION

3.1 GENERAL

A. All tests performed on optical fiber cabling that use a laser or LED in a test set shall be carried out with safety precautions in accordance with ANSI Z136.2.

B. All outlets, cables, patch panels and associated components shall be fully assembled and labeled prior to field-testing. Any testing performed on incomplete systems shall be redone on completion of the work.

3.2 OPTICAL FIBER CABLE TESTING

A. Field-test instruments shall have the latest software and firmware installed.

B. Link and channel test results from the OLTS and OTDR shall be recorded in the test instrument upon completion of each test for subsequent uploading to a PC in which the administrative documentation (reports) may be generated.

C. Fiber end faces shall be inspected at 200X or 400X magnification. 200X magnification is suitable for inspecting multimode and single mode fibers. 400X magnification may be used for detailed examination of single mode fibers. Scratched, pitted or dirty connectors shall be diagnosed and corrected.

   1. It is preferable that the end face images be recorded in the memory of the test instrument for subsequent uploading to a PC and reporting.

D. Testing shall be performed on each cabling segment (connector to connector).

E. Testing shall be performed on each cabling channel (equipment to equipment) that is planned for use per the owner's instructions.

F. Testing of the cabling shall be performed using high-quality test cords of the same fiber type as the cabling under test. The test cords for OLTS testing shall be between 1 m and 5 m in length. The test cords for OTDR testing shall be approximately 100 m for the launch cable and at least 25 m for the receive cable.

G. Optical loss testing

1. Horizontal/Backbone link
   a. Multimode links shall be tested at 850 nm and 1300 nm in accordance with ANSI/TIA-526-14-B, one-cord reference method.
   b. Single mode backbone links shall be tested at 1310 nm and 1550 nm in accordance with ANSI/TIA/EIA-526-7, Method A.1, One Reference Jumper equivalent method.
   c. Link attenuation does not include any active devices or passive devices other than cable, connectors, and splices, i.e. link attenuation does not include such devices as optical bypass switches, couplers, repeaters, or optical amplifiers.

H. OTDR Testing

1. Fiber links shall be tested at these wavelengths for anomalies and to ensure uniformity of cable attenuation, connector insertion loss and reflectance.
   a. Multimode: 850 nm and 1300 nm.
   b. Single mode: 1310 nm and 1550 nm.
2. Each fiber link and channel shall be tested in both directions.
3. A launch cable shall be installed between the OTDR and the first link connection.
4. A tail cable shall be installed after the last link connection.

I. Magnified End face Inspection

1. Fibers shall be inspected at 250X or 400X magnification. 250X magnification is suitable for inspecting multimode and single mode fibers. 400X magnification may be used for detailed examination of single mode fibers.

J. Length Measurement

1. The length of each fiber shall be recorded.
2. It is preferable that the optical length be measured using an OLTS or OTDR.

K. Polarity Testing

1. Paired duplex fibers in multi-fiber cables shall be tested to verify polarity in accordance with Clause E.5.3 of ANSI/TIA-568-C.0. The polarity of the paired duplex fibers shall be verified using an OLTS.

3.3 IDENTIFICATION

A. Labeling

1. Labeling shall conform to the requirements specified within ANSI/TIA-606-B or to the requirements specified by the Owner or the Owner’s representative.

3.4 ADMINISTRATION

A. Test results documentation

1. Test results saved within the field-test instrument shall be transferred into a Windows™-based database utility that allows for the maintenance, inspection and archiving of the test records. These test records shall be uploaded to the PC unaltered, i.e., “as saved in the field-test instrument”. The following formats do not provide adequate protection of these records and shall not be used.
2. The test results documentation shall be available for inspection by the Owner or the Owner’s representative during the installation period and shall be passed to the Owner's representative within 5 working days of completion of tests on cabling served by a telecommunications room or of backbone cabling. The installer shall retain a copy to aid preparation of as-built information.
3. The database for the complete project, including twisted-pair copper cabling links, if applicable, shall be stored and delivered on CD/DVD prior to Owner acceptance of the building in the original format used by the cabling vendors’ software.
4. Circuit IDs reported by the test instrument should match the specified label ID (see 3.3 of this Section).
5. The detailed test results documentation data is to be provided in an electronic database for each tested optical fiber and shall contain the following information
   a. The identification of the customer site as specified by the end-user.
   b. The name of the test limit selected to execute the stored test results.
   c. The name of the personnel performing the test.
   d. The date and time the test results were saved in the memory of the tester.
   e. The manufacturer, model and serial number of the field-test instrument.
   f. The version of the test software and the version of the test limit database held within the test instrument.
   g. The fiber identification number.
   h. The length for each optical fiber.
   i. The index of refraction used for length calculation when using length capable OLTS.
   j. The backscatter coefficient of the fiber under test when using an OTDR.
   k. Test results to include OLTS attenuation link and channel measurements at the appropriate wavelength(s) and the margin (difference between the measured attenuation and the test limit value).
   l. Test results to include OTDR link and channel traces, event tables at the appropriate wavelength(s) and a map of the link tested.
   m. The length for each optical fiber as calculated by the OTDR.
   n. The overall Pass/Fail evaluation of the link-under-test for OLTS and OTDR measurements

B. Record copy and as-built drawings

1. Provide record copy drawings periodically throughout the project as requested by the Construction Manager or Owner, and at end of the project on CD/DVD. Record copy drawings at the end of the project shall be in CAD format and include notations reflecting the as built conditions of any additions to or variation from the drawings provided such as, but not limited to cable paths and termination point. CAD drawings are to incorporate test data imported from the test instruments.
2. The as-built drawings shall include, but are not limited to block diagrams, frame and cable labeling, cable termination points, equipment room layouts and frame installation details. The as-built shall include all field changes made up to construction completion:
   a. Field directed changes to pull schedule.

b. Field directed changes to cross connect and patching schedule.
c. Horizontal cable routing changes.
d. Backbone cable routing or location changes.
e. Associated detail drawings.

End of Section

Section 27 17 20

TESTING CATEGORY 6A TWIST PAIR INFRASTRUCTURE

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. Provide all labor, materials, tools, field-test instruments and equipment required for the complete testing, identification and administration of the work called for in the Contract Documents.

B. In order to conform to the overall project event schedule, the cabling contractor shall survey the work areas and coordinate cabling testing with other applicable trades.

C. In addition to the tests detailed in this document, the contractor shall notify the Owner or the Owner’s representative of any additional tests that are deemed necessary to guarantee a fully functional system. The contractor shall carry out and record any additional measurement results at no additional charge.

1.4 SCOPE

A. This Section includes the minimum requirements for the test certification, identification and administration of horizontal balanced twisted pair cabling.

B. This Section includes minimum requirements for:

1. Copper cabling test instruments
2. Copper cabling testing
3. Identification
    a. Labels and labeling

4. Administration
    a. Test results documentation

b. As-built drawings

C. Testing shall be carried out in accordance with this document.

D. Testing shall be performed on each cabling link. (100% testing)

E. All tests shall be documented.

1.5 QUALITY ASSURANCE

A. All testing procedures and field-test instruments shall comply with applicable requirements of:

1. ANSI/TIA-1152, Requirements for Field Test Instruments and Measurements for Balanced Twisted-Pair Cabling
2. ANSI/TIA-568-C.0, Generic Telecommunications Cabling for Customer Premises.
3. ANSI/TIA-568-C.1, Commercial Building Telecommunications Cabling Standard
4. ANSI/TIA 568 C.2, Balanced Twisted-Pair Telecommunications Cabling and Components Standards.
5. ANSI/TIA-606-B, Administration Standard for Commercial Telecommunications Infrastructure, including the requirements specified by the customer, unless the customer specifies their own labeling requirements.

B. Trained technicians who have successfully attended an appropriate training program and have obtained a certificate as proof thereof shall execute the tests. These certificates may have been issued by any of the following organizations or an equivalent organization:

1. Manufacturer of the connectors or cable.
2. Manufacturer of the test equipment used for the field certification.
3. Training organizations (e.g., BICSI, A Telecommunications Association headquarters in Tampa, Florida; ACP [Association of Cabling Professionals™] Cabling Business Institute located in Dallas, Texas)

C. The Owner or the Owner’s representative shall be invited to witness and/or review field-testing.

1. The Owner or the Owner’s representative shall be notified of the start date of the testing phase five (5) business days before testing commences.
2. The Owner or the Owner’s representative will select a random sample of 5% of the installed links. The Owner or the Owner’s representative shall test these randomly selected links and the results are to be stored in accordance with Part 3 of this document. The results obtained shall be compared to the data provided by the installation contractor. If more than 2% of the sample results differ in terms of the pass/fail determination, the installation contractor under supervision of the representative shall repeat 100% testing at no cost to the Owner.

1.6 SUBMITTALS

A. Manufacturers catalog sheets and specifications for the test equipment.

B. A schedule (list) of all balanced twisted-pair copper links to be tested.

C. Sample test reports.

1.7 ACCEPTANCE OF TEST RESULTS

A. Unless otherwise specified by the Owner or the Owners representative, each cabling link shall be in tested for:

1. Wire Map
2. Length
3. Propagation Delay
4. Delay Skew
5. DC Loop Resistance – recorded for information only
6. DC Resistance Unbalance – recorded for information only
7. Insertion Loss
8. NEXT (Near-End Crosstalk)
9. PS NEXT (Power Sum Near-End Crosstalk)
10. ACR-N (Attenuation to Crosstalk Ratio Near-End) – recorded for information only
11. PS ACR-N (Power Sum Attenuation to Crosstalk Ratio Near-End) – recorded for information only
12. ACR-F (Attenuation to Crosstalk Ratio Far-End)
13. PS ACR-F (Power Sum Attenuation to Crosstalk Ratio Far-End)
14. Return Loss
15. TCL (Transverse Conversion Loss) – recorded for information only
16. ELTCTL (Equal Level Transverse Conversion Transfer Loss) – recorded for information only
17. PS ANEXT (Power Sum Alien Near-End Crosstalk) – sampled per section 3.2
18. Average PS ANEXT (Average Power Sum Alien Near-End Crosstalk) – sampled per section 3.2
19. PS AACR-F (Power Sum Alien Attenuation to Crosstalk Ratio Far-End) – sampled per section 3.2
20. Average PS AACR-F (Average Power Sum Alien Attenuation to Crosstalk Ratio Far-End) – sampled per section 3.2

B. All installed cabling Permanent Links shall be field-tested and pass the test requirements and analysis as described in Part 3. Any Permanent Link that fails these requirements shall be diagnosed and corrected. Any corrective action that must take place shall be documented and followed with a new test to prove that the corrected Permanent Link meets performance requirements. The final and passing result of the tests for all Permanent Links shall be provided in the test results documentation in accordance with Part 3.

C. Acceptance of the test results shall be given in writing after the project is fully completed and tested in accordance with Contract Documents and to the satisfaction of the Owner.

PART 2 - PRODUCTS

2.1 BALANCED TWISTED-PAIR CABLE TESTERS

A. The field-test instrument shall be within the calibration period recommended by the manufacturer, typically 12 months.

B. Certification tester

1. Accuracy
   a. Level IIIe accuracy in accordance with ANSI/TIA-1152
   b. Independent verification of accuracy

2. Permanent Link Adapters
   a. RJ45 plug must meet the requirements for NEXT, FEXT and Return Loss in accordance with ANSI/TIA-568-C.2 Annex C
   b. Twisted pair Category 5e, 6, 6A, 7 or 7A cords are not permitted as their performance degrades with use and can cause false Return Loss failures

3. Results Storage
   a. Must be capable of storing > 10,000 results for all measurements found in 2.1.B.4 below

4. Measurement capabilities
   a. Wire Map
   b. Length
   c. Propagation Delay
   d. Delay Skew
   e. DC Loop Resistance
   f. DC Resistance Unbalance
   g. Insertion Loss
   h. NEXT (Near-End Crosstalk)
   i. PS NEXT (Power Sum Near-End Crosstalk)
   j. ACR-N (Attenuation to Crosstalk Ratio Near-End)
   k. PS ACR-N (Power Sum Attenuation to Crosstalk Ratio Near-End)
   l. ACR-F (Attenuation to Crosstalk Ratio Far-End)
   m. PS ACR-F (Power Sum Attenuation to Crosstalk Ratio Far-End)
   n. Return Loss
   o. TCL (Transverse Conversion Loss)
   p. ELTCTL (Equal Level Transverse Conversion Transfer Loss)
   q. Time Domain Reflectometer
   r. Time Domain Xtalk Analyzer
   s. PS ANEXT (Power Sum Alien Near-End Crosstalk)
   t. Average PS ANEXT (Average Power Sum Alien Near-End Crosstalk)
   u. PS AACR-F (Power Sum Alien Attenuation to Crosstalk Ratio Far-End)
   v. Average PS AACR-F (Average Power Sum Alien Attenuation to Crosstalk Ratio Far-End)

5. PC Software
   a. Windows® based.
   b. Must show when 3 dB and 4 dB rules are applied
   c. Re-certification capability, where results must have their Cable IDs suffixed with (RC).
   d. Built in PDF export – no additional third party software permitted.
   e. Built-in statistical analysis.

2.2 IDENTIFICATION

A. Labels

1. Shall meet the legibility, defacement, exposure and adhesion requirements of UL 969.
2. Shall be preprinted using a mechanical means of printing (e.g., laser printer).
3. Where used for cable marking, provide vinyl substrate with a white printing area and a clear “tail” that self laminates the printed area when wrapped around the cable. If cable jacket is white, provide cable label with printing area that is any other color than white, preferably orange or yellow – so that the labels are easily distinguishable.
4. Where insert type labels are used provide clear plastic cover over label.

5. Provide plastic warning tape 6 inches wide continuously printed and bright colored 18" above all direct buried services, underground conduits and duct-banks.
6. Acceptable Manufacturers:
   a. Brady Corporation
   b. Silver Fox
   c. Brothers
   d. Or approved equal

2.3 ADMINISTRATION

A. Administration of the documentation shall include test results of each Permanent Link.

B. The test result information for each link shall be recorded in the memory of the field-test instrument upon completion of the test.

C. The test result records saved within the field-test instrument shall be transferred into a Windows® -based database utility that allows for the maintenance, inspection and archiving of these test records.

D. Alien Crosstalk measurements shall be stored to a PC upon completion of the test.

PART 3 - EXECUTION

3.1 GENERAL

A. All outlets, cables, patch panels and associated components shall be fully assembled and labeled prior to field-testing. Any testing performed on incomplete systems shall be redone on completion of the work.

3.2 BALANCED TWISTED PAIR CABLE TESTING

A. Field-test instruments shall have the latest software and firmware installed.

B. Permanent Link test results including the individual frequency measurements from the tester shall be recorded in the test instrument upon completion of each test for subsequent uploading to a PC in which the administrative documentation (reports) may be generated.

C. Permanent Link testing shall be performed on each cabling segment (connector to connector). Sampling is not acceptable.

D. Alien Crosstalk testing shall be performed using a sampling plan. An acceptance quality level (AQL) of 0,4 %, normal inspection, general inspection level I as defined in ISO 2859-1 for populations of up to 500,000 links shall be used. The following table represents this sampling level. Disturbed (Victim) links chosen for Alien Crosstalk testing shall be an equal combination of short, medium and long links.

Installation size (No. of total links)	**Sample size (No. of links to test)**
3 – 33	100%
34 – 3,200	33

3,201 – 35,000	126
35,001 – 150,000	201
150,001 – 500,000	315

E. Permanent Link adapters made from twisted pair Category 5e, 6, 6A, 7 or 7A cords are not permitted as their performance degrades with use and can cause false Return Loss failures.

F. The installer shall build a reference link. All components shall be anchored so it is not possible to disturb them. The technician is to conduct a Category 6A Permanent Link test each day to ensure no degradation of the tester or its Permanent Link adapters.

G. Wire Map Measurement

1. The wire map test is intended to verify pin-to-pin termination at each end and check for installation connectivity errors. For each of the 8 conductors in the cabling, the wire map indicates:
   a. Continuity to the remote end
   b. Shorts between any two or more conductors
   c. Reversed pairs
   d. Split pairs
   e. Transposed pairs
   f. Distance to open on shield
   g. Any other miss-wiring

2. The correct connectivity of telecommunications outlets/connectors is defined in ANSI/TIA-568-C.2. Two color schemes are permitted. The user shall define which scheme is to be used. The field tester shall document which color scheme was used.

H. Length Measurement

1. The length of each balanced twisted pair shall be recorded.
2. Since physical length is determined from electrical length, the physical length of the link calculated using the pair with the shortest electrical delay shall be reported and used for making the pass or fail determination.
3. The pass or fail criteria is based on the maximum length allowed for the Permanent Link as specified in ANSI/TIA-568-C.2 plus the nominal velocity of propagation (NVP) uncertainty of 10%. For a Permanent Link, the length measurement can be 325 ft. (99 m) before a fail is reported.

I. Propagation Delay measurement

1. Is the time it takes for a signal to reach the end of the link.
2. The measurement shall be made at 10 MHz per ANSI/TIA-1152.
3. The propagation delay of each balanced twisted pair shall be recorded.
4. Is not to exceed 498 ns per ANSI/TIA-568-C.2 Section 6.3.18.

J. Delay Skew measurement

1. Is the difference in propagation delay @ 10 MHz between the shortest delay and the delays of the other wire pairs.
2. The delay skew of each balanced twisted pair shall be recorded.
3. Is not to exceed 44 ns per ANSI/TIA-568-C.2 Section 6.3.19.

K. DC Resistance

1. Often reported as Resistance, is the loop resistance of both conductors in the pair.
2. Is not specified in ANSI/TIA-1152 but shall be recorded for all four pairs.

L. DC Resistance Unbalance

1. Often reported as Resistance Unbalance, is the difference in resistance of the two wires within the pair.
2. Is not specified in ANSI/TIA-1152 for a Permanent Link but shall be recorded for all four pairs.

M. Insertion Loss

1. Is the loss of signal strength over the cabling (in dB).
2. The frequency resolution shall be:
   a. 1 – 31.25 MHz: 150 kHz
   b. 31.25 – 100 MHz: 250 kHz
   c. 100 – 250 MHz: 500 kHz
   d. 250 – 500 MHz: 1000 kHz
3. Worst case shall be reported for all four pairs in one direction only.
4. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
5. Is not to exceed the Category 6A Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.7.

N. NEXT (Near-End Crosstalk)

1. Is the difference in amplitude (in dB) between a transmitted signal and the crosstalk received on other wire pairs at the same end of the cabling.
2. The frequency resolution shall be:
   a. 1 – 31.25 MHz: 150 kHz
   b. 31.25 – 100 MHz: 250 kHz
   c. 100 – 250 MHz: 500 kHz
   d. 250 – 500 MHz: 1000 kHz
3. Shall be measured in both directions. (12 pair to pair possible combinations)
4. Both worst case and worst margins shall be reported.
5. Is not to exceed the Category 6A Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.8.
6. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
7. The Time Domain Xtalk data shall be stored for any marginal or failing NEXT results.

O. PS NEXT (Power Sum Near-End Crosstalk)

1. Is the difference (in dB) between the test signal and the crosstalk from the other pairs received at the same end of the cabling.
2. The frequency resolution shall be:
   a. 1 – 31.25 MHz: 150 kHz
   b. 31.25 – 100 MHz: 250 kHz
   c. 100 – 250 MHz: 500 kHz
   d. 250 – 500 MHz: 1000 kHz

3. Shall be measured in both directions. (8 pair possible combinations)
4. Both worst case and worst margins shall be reported.
5. Is not to exceed the Category 6A Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.9.
6. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
7. The Time Domain Xtalk data shall be stored for any marginal or failing PS NEXT results.

P. ACR-N (Attenuation Crosstalk Ratio Near-End)

1. Is a calculation of NEXT minus Insertion Loss of the disturbed pair in dB.
2. The frequency resolution shall be:
   a. 1 – 31.25 MHz: 150 kHz
   b. 31.25 – 100 MHz: 250 kHz
   c. 100 – 250 MHz: 500 kHz
   d. 250 – 500 MHz: 1000 kHz
3. Shall be calculated in both directions.
4. Is not specified in ANSI/TIA-1152, but shall be recorded for all 12 possible combinations.

Q. PS ACR-N (Power Sum Attenuation Crosstalk Ratio Near-End)

1. Is a calculation of PS NEXT minus Insertion Loss of the disturbed pair in dB.
2. The frequency resolution shall be:
   a. 1 – 31.25 MHz: 150 kHz
   b. 31.25 – 100 MHz: 250 kHz
   c. 100 – 250 MHz: 500 kHz
   d. 250 – 500 MHz: 1000 kHz
3. Shall be calculated in both directions.
4. Is not specified in ANSI/TIA-1152, but shall be recorded for all 8 possible combinations.

R. ACR-F (Attenuation Crosstalk Ratio Far-End)

1. Is a calculation of FEXT minus Insertion Loss of the disturbed pair in dB.
2. The frequency resolution shall be:
   a. 1 – 31.25 MHz: 150 kHz
   b. 31.25 – 100 MHz: 250 kHz
   c. 100 – 250 MHz: 500 kHz
   d. 250 – 500 MHz: 1000 kHz
3. Shall be measured in both directions. (24 pair to pair possible combinations)
4. Both worst case and worst margins shall be reported.
5. Is not to exceed the Category 6A Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.11.
6. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).

S. PS ACR-F (Power Sum Attenuation to Crosstalk Ratio Far-End)

1. Is a calculation of PS FEXT minus Insertion Loss of the disturbed pair in dB.
2. The frequency resolution shall be:
   a. 1 – 31.25 MHz: 150 kHz
   b. 31.25 – 100 MHz: 250 kHz

c. 100 – 250 MHz: 500 kHz
d. 250 – 500 MHz: 1000 kHz

3. Shall be measured in both directions. (8 pair possible combinations)
4. Both worst case and worst margins shall be reported.
5. Is not to exceed the Category 6A Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.13.
6. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).

T. Return Loss

1. Is the difference (in dB) between the power of a transmitted signal and the power of the signals reflected back.
2. The frequency resolution shall be:
   a. 1 – 31.25 MHz: 150 kHz
   b. 31.25 – 100 MHz: 250 kHz
   c. 100 – 250 MHz: 500 kHz
   d. 250 – 500 MHz: 1000 kHz

3. Shall be measured in both directions. (8 pair possible combinations)
4. Both worst case and worst margins shall be reported.
5. Shall be ignored at all frequencies where the Insertion Loss is less than 3 dB for that pair.
6. Is not to exceed the Category 6A Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.6.
7. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
8. The Time Domain Reflectometer data shall be stored for any marginal or failing Return Loss results.

U. TCL (Transverse Conversion Loss)

1. Is the ratio (in dB) between a differential mode signal inject at the near-end and the common-mode signal measured at the near-end on the same wire pair.
2. The frequency resolution shall be:
   a. 1 – 31.25 MHz: 150 kHz
   b. 31.25 – 100 MHz: 250 kHz
   c. 100 – 250 MHz: 500 kHz
   d. 250 – 500 MHz: 1000 kHz

3. Shall be measured in both directions.
4. Is not specified in ANSI/TIA-1152 for a Permanent Link, but shall be recorded for all 8 possible combinations.

V. ELTCTL (Equal Level Transverse Conversion Transfer Loss)

1. Is the ratio (in dB) between a differential mode signal inject at the near-end and the common-mode signal measured at the far end on the same wire pair minus the Insertion Loss of that pair.
2. The frequency resolution shall be:
   a. 1 – 31.25 MHz: 150 kHz
   b. 31.25 – 100 MHz: 250 kHz
   c. 100 – 250 MHz: 500 kHz
   d. 250 – 500 MHz: 1000 kHz

3. Shall be measured in both directions.
4. Is not specified in ANSI/TIA-1152 for a Permanent Link, but shall be recorded for all 8 possible combinations.

W. PS ANEXT (Power Sum Alien Near-End Crosstalk)

1. Takes into account the combined alien crosstalk (statistical) on a receive pair from all external near-end disturbers operating simultaneously.
2. The frequency resolution shall be:
   a. 1 – 31.25 MHz: 150 kHz
   b. 31.25 – 100 MHz: 250 kHz
   c. 100 – 250 MHz: 500 kHz
   d. 250 – 500 MHz: 1000 kHz
3. The disturbed (victim) link shall have links to the left and right of it and if present, links above and below it.
4. Disturber cables shall include all links within the same bundle as the disturbed (victim) link and adjacent links
5. Should be measured in both directions if the link is patch panel to patch panel. If the link is patch panel to telecommunications outlet, then it shall be measured from the patch panel end only.
6. Is not to exceed the Category 6A Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.21.

X. Average PS ANEXT (Power Sum Alien Near-End Crosstalk)

1. Is calculated by averaging the individual PSANEXT loss values, in dB, for all four pairs in the disturbed (victim) link.
2. The frequency resolution shall be:
   a. 1 – 31.25 MHz: 150 kHz
   b. 31.25 – 100 MHz: 250 kHz
   c. 100 – 250 MHz: 500 kHz
   d. 250 – 500 MHz: 1000 kHz
3. Is not to exceed the Category 6A Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.22.

Y. PS AACR-F (Power Sum Alien Attenuation to Crosstalk Ratio Far-End)

1. AFEXT loss is the coupling of crosstalk at the far-end from external link pairs into a disturbed (victim) pair of the 4-pair link under test. PS AACR-F is the calculated power sum from all external pairs into the disturbed (victim) pair.
2. The frequency resolution shall be:
   a. 1 – 31.25 MHz: 150 kHz
   b. 31.25 – 100 MHz: 250 kHz
   c. 100 – 250 MHz: 500 kHz
   d. 250 – 500 MHz: 1000 kHz
3. The disturbed (victim) link shall have links to the left and right of it and if present, links above and below it.
4. Disturber cables shall include all links within the same bundle as the disturbed (victim) link and adjacent links

5. Should be measured in both directions if the link is patch panel to patch panel. If the link is patch panel to telecommunications outlet, then it shall be measured from the patch panel end only.
6. Is not to exceed the Category 6A Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.25.

Z. Average PS AACR-F (Power Sum Alien Attenuation to Crosstalk Ratio Far-End)

1. Is calculated by averaging the individual PS AACR-F values, in dB, for all four pairs in the disturbed (victim) link.
2. The frequency resolution shall be:
   a. 1 – 31.25 MHz: 150 kHz
   b. 31.25 – 100 MHz: 250 kHz
   c. 100 – 250 MHz: 500 kHz
   d. 250 – 500 MHz: 1000 kHz
3. The disturbed (victim) link shall have links to the left and right of it and if present, links above and below it.
4. Disturber cables shall include all links within the same bundle as the disturbed (victim) link and adjacent links
5. Should be measured in both directions if the link is patch panel to patch panel. If the link is patch panel to telecommunications outlet, then it shall be measured from the patch panel end only.
6. Is not to exceed the Category 6A Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.26.

3.3 ADMINISTRATION

A. Test results documentation

1. Test results saved within the field-test instrument shall be transferred into a Windows™-based database utility that allows for the maintenance, inspection and archiving of the test records. These test records shall be uploaded to the PC unaltered, i.e., “as saved in the field-test instrument”. The file format, CSV (comma separated value), does not provide adequate protection of these records and shall not be used.
2. The test results documentation shall be available for inspection by the Owner or the Owner’s representative during the installation period and shall be passed to the Owner's representative within 5 working days of completion of tests on cabling served by a telecommunications room or of backbone cabling. The installer shall retain a copy to aid preparation of as built information.
3. The database for the complete project, including twisted-pair copper cabling links, if applicable, shall be stored and delivered on CD or DVD prior to Owner acceptance of the building. This CD or DVD shall include the software tools required to view, inspect, and print any selection of the test reports.
4. Circuit IDs reported by the test instrument should match the specified label ID (see 3.3 of this Section).
5. For Permanent Link testing, the detailed test results documentation data is to be provided in an electronic database for each tested balance twisted-pair and shall contain the following information
   a. The overall Pass/Fail evaluation of the link-under-test
   b. The date and time the test results were saved in the memory of the tester
   c. The identification of the customer site as specified by the end-user
   d. The name of the test limit selected to execute the stored test results
   e. The name of the personnel performing the test

f. The version of the test software and the version of the test limit database held within the test instrument
g. The manufacturer, model and serial number of the field-test instrument
h. The adapters used
i. The factory calibration date
j. Wire Map
k. Propagation Delay values, for all four pairs
l. Delay Skew values, for all four pairs
m. DC Resistance values, for all four pairs
n. DC Resistance Unbalance, values for all four pairs
o. Insertion Loss, worst case values for all four pairs
p. NEXT, worst case margin and worst case values, both directions
q. PS NEXT, worst case margin and worst case values, both directions
r. ACR-F, worst case margin and worst case values, both directions
s. PS ACR-F, worst case margin and worst case values, both directions
t. Return Loss, worst case margin and worst case values, both directions
u. TCL, worst case values both directions
v. ELTCTL, worst case values, both directions.
w. Time Domain Crosstalk data if the link is marginal or fails
x. Time Domain Reflectometer data if the link is marginal or fails

6. For Alien Crosstalk testing, the detailed test results documentation data is to be provided in an electronic database for each tested balance twisted-pair and shall contain the following information
   a. The overall Pass/Fail evaluation of the link-under-test
   b. The date and time the measurements were made
   c. The identification of the customer site as specified by the end-user
   d. The name of the test limit selected to execute the stored test results
   e. The name of the personnel performing the test
   f. The version of the test software
   g. PS ANEXT, worst case margin for all four pairs
   h. Average PS ANEXT, worst case margin
   i. PS AACR-F, worst case margin for all four pairs
   j. Average PS AACR-F, worst case margin

B. Record copy and as-built drawings

1. Provide record copy drawings periodically throughout the project as requested by the Construction Manager or Owner, and at end of the project on a CD or DVD. Record copy drawings at the end of the project shall be in CAD format and include notations reflecting the as built conditions of any additions to or variation from the drawings provided such as, but not limited to cable paths and termination point. The as built drawings shall include, but are not limited to block diagrams, frame and cable labeling, cable termination points, equipment room layouts and frame installation details. The as-builts shall include all field changes made up to construction completion:
   a. Field directed changes to pull schedule.
   b. Horizontal cable routing changes.
   c. Associated detail drawings.

End of Section

Section 27 21 00

DATA COMMUNICATIONS NETWORK EQUIPMENT

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

TO BE ISSUED BY ADDENDA

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. It is the intent of these specifications that the Vendor, Manufacturer and/or its Authorized System Integrator expeditiously furnishes and installs a system complete in every respect and ready to operate. All miscellaneous items and accessories required for such installation, whether or not each such item or accessory is shown on the plans or mentioned in these specifications, shall be furnished and installed.

B. The data network communications equipment shall be installed as shown on the drawings and as specified herein. The work covered by this section of the specifications includes the furnishing of all labor, equipment, materials and performance of all operations associated with the data network communications equipment for a fully functional system.

C. The school district has standardized on Hewlett Packard (HP) wired LAN equipment and on Cisco wireless LAN equipment. This Contractor shall provide HP 5400 series chassis switches and Cisco Meraki MR 53 Wi-Fi access points as specified herein.

1.4 PROGRAMMING

A. Coordinate and obtain a written approval of system functionality from the Owner prior to programming.

B. Perform a walk-through with the Owner and demonstrate the system functionality.

Section 27 30 00

AREA OF REFUGE SYSTEM

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. Area of refuge system including but not limited to:

1. Command Center
2. Distribution Box
3. Call Boxes
4. Battery Backup
5. Signage
6. Power Supplies
7. 2-hour rated wiring

1.4 REFERENCES

A. Federal Communications Commission (FCC):

1. FCC Part 15 - Radio Frequency Device.
2. FCC Part 68 - Connection of Terminal Equipment to the Telephone Network.
3. FCC Compliance to applicable Regulations and Display a valid FCC ID on the Product and/or have a valid FCC license for operation

B. National Fire Protection Association (NFPA):

1. NFPA70 - National Electrical Code.

C. Underwriters Laboratories (UL):

1. UL294 - Access Control System Units.

2. ITE UL 60950, #E218113

D. U. S. Federal Drug Administration (FDA):

1. FDA Listed under CFR Title 21 Section 890.3725 and produced by an FDA registered manufacturer

1.5 APPLICABLE CODES & STANDARDS

A. The Contractor shall ensure that all Work provided under this section shall meet the minimum requirements of all applicable codes and standards, as determined by the AHJ.

B. Where the requirements of this section exceed the minimum requirements of the AHJ, this section shall govern. Where codes conflict with the Contract Documents, codes shall govern. Where any applicable codes and standards conflict between themselves, the more stringent shall apply.

C. Nothing in this section shall relieve Contractor from the responsibility for compliance with all applicable codes, standards or specifications which are generally recognized to be applicable to the Work specified herein.

D. Contractor shall make application for and obtain any and all permits required by federal, state, county, city or other AHJ over the work. In the event that inspections are required, it shall be the responsibility of Contractor to schedule and ensure the completion of said inspections and to ensure that all necessary certificates are issued, obtained, and delivered to the Owner.

E. Within this Section and the Subsystem Specifications, reference is made to United States-based standards, codes and legislation. For projects outside the United States, the corresponding local codes, standards and legislation shall apply, except where local requirements are less stringent than those proscribed within the referenced United States requirements. In these cases, the referenced United States requirements shall apply.

1.6 SUBMITTALS

A. Comply with Division 01.

B. Shop drawings

1. Shop drawings shall be computer generated in AutoCAD® version 2010, VISIO or similar software and shall be precisely scaled. Free-hand sketches or reproductions of Contract Documents shall not be acceptable.
2. Coordinate with the Owner's Representative to obtain architectural backgrounds in electronic or hardcopy format for use in the shop drawings.
3. Shop drawings shall consist, at a minimum, of the following:
   a. Floor plan drawings indicating the location of all devices as well as all wire runs and designations.
   b. Plans, elevations and details indicating dimensions, gages, reinforcement, anchorage, and other installation details for each device as required.
   c. System point-to-point diagram indicating the inter-relationship of all system peripheral devices, control panels, software / monitoring workstations, and other components as necessary for a complete and operational system.
   d. Typical wiring diagrams for each system peripheral device.

e. Specific wiring diagrams for each system control panel, power supply, video recorder, fire system interface, emergency call system interface or other device or equipment that controls or communicates with multiple peripheral devices.
f. Fabrication shop drawings for all custom equipment.

C. Record Drawings: Contractor shall maintain up-to-date record drawings on site for inspection by the Owner's Representative. Each change to the original approved submittal data and deviation from the Contract Documents shall be indicated on the record drawings. Contractor shall ensure that the record drawings are protected against soiling, tears, or other damage or defacement. At the conclusion of the Project the Contractor shall incorporate all changes on the record drawings into electronic format and shall submit the completed set as as-built documentation as defined in the section titled "Record documentation" herein.

D. Product data

1. All product data for the Project shall be tabulated into a comprehensive list of equipment to be provided for the Project, including quantities, manufacturer names, model numbers, description and any applicable options. The product data submittal shall be of sufficient detail that the Owner's Representative may readily identify the equipment and materials proposed.
2. Provide all product data in electronic format on CD or USB thumb drive.
3. Product data shall consist, at a minimum, of the following:
   a. Product data sheets for each piece of equipment included in the project identifying the following:
      1) Materials and Fabrication
      2) Tolerances
      3) Power and environmental / HVAC requirements
      4) Special criteria related to particular systems and components.
      5) Specifically, and clearly mark items submitted where multiple items and options occur on a sheet.
      6) Identify all Parts and Components by name and manufacturer's number.
   b. Manufacturers' brochures for each of the system components included. Contractor shall submit original brochures; copies shall not be acceptable. Where information is in color, all copies shall be provided in color.
   c. Schedules shall independently identify each piece of equipment, component and device provided for the project including project name/number reference, product name and number, installation location and conductor/cable identifications that devices are connected to.
      1) Reference both manufacturer and construction document identification.
      2) For information submitted in a schedule, include information independently in an organized and consistent format.
      3) Provide programming point information within the schedules.
   d. At the request of the Owner's Representative and as identified in Subsystem Specifications, submit color samples for specific pieces of equipment.
   e. Where test data is required by the Subsystem Specifications or Project General Conditions, all tests must be specific to products supplied specific for this project.

4. Certificates and Testing Information:
   a. Provide a manufacturer's certificate certifying that Products meet or exceed specified requirements.
   b. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency.

5. The Owner's Representative shall have the right to request additional information as required for a proper review of the submittal information.

E. Operation and Maintenance Data: Submit manufacturer's operation and maintenance data, customized to the system installed. Include system and operator or user manuals.

1.7 QUALITY ASSURANCE

A. The Manufacturer shall be equipped to support the end-user with around-the-clock live support (24/7/365) with direct access to technical support specialists to help accelerate issue resolutions and offer software upgrades as part of a maintenance program offering. The manufacturer shall offer remote technical support capability, including the ability to remotely access system resources and resolve issues.

1.8 PRODUCT DELIVERY, STORAGE AND HANDLING

A. Deliver, store and handle products in accordance with manufacturer's recommendations, so as to minimize the opportunity for damage, deterioration, or loss.

B. The Owner assumes no liability or responsibility for loss by theft, vandalism, burglary of material or equipment stored on site.

C. Deliver all equipment and material to the site in the manufacturer's original sealed packaging. Packaging is to provide factory identification of items contained within the packaging, and protection until the items or materials are installed. Inspect all equipment and material upon delivery to ensure that they are free from damage and in accordance with the Contract Documents.

D. Upon arrival, contractor should observe products for unacceptable conditions and/or damage. Acceptance of the products constitutes the contractor's acknowledgment that products or materials are satisfactory for use.

E. Store products in their original packaging until installation. Protect from soilage, moisture, all weather-related conditions, corrosion, breakage or other damaging elements. Store in conditions that will insure all required manufacturer's environmental criteria are maintained until use of material or products.

1.9 CONTRACTOR QUALIFICATIONS

A. The Contractor shall be in the trade of installing and servicing area of refuge systems for a minimum of 5 years.

1.10 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers

1. Rath.
2. Alpha Communications.
3. Cornell.
4. Or approved equal.

2.2 BASIS OF DESIGN

A. Basis of design product shall be by RATH® and represents the performance standard upon which any equivalent solution shall be based.

2.3 SYSTEM REQUIREMENTS

A. The Command Center is to be located at a central control point on the first floor or as determined by local Authority Having Jurisdiction. RATH® Command Center Call Boxes are to be located on all floors above and below the first floor, ideally next to a stairwell emergency exit or elevator landing on each floor.

B. The Command Center must include visual indicators to allow rescue personnel to know which Call Box needs assistance. The Command Center must allow rescue personnel to speak to each Call Box individually. The Command Center must include both a handset and speakerphone to communicate back to the Call Boxes.

C. The emergency communication hardware shall comply with the Americans with Disabilities Act (ADA). The Call Boxes shall have the ability to be programmed with up to 2 emergency phone numbers (either both off-site or Base Station and one off-site). Upon activation of the emergency push button, a call will be automatically placed to the Command Center. If no one answers at the Command Center, the Call Box must dial a secondary location outside the building to activate two-way off-site person to person voice communications via landline.

2.4 CONSTRUCTION

A. The Command Center (2500 series) shall include both the Base Station and Distribution Module. The Base Station must have a powder coated steel housing (surface or flush mount) or be desk mounted, include a black handset with coil cord and be powered from the Distribution Module.

B. Distribution Module must be a surface mount enclosure, include connections for the Call Boxes and power both the Base Station and 2400 series Call Boxes. The Distribution Module shall be powered from 120vac power with a battery backup that provides power for a minimum of 4 hours (part # RP7701500 for 56-Up Zone).

C. The Call Boxes (2400 series) must be in full compliance with ADA requirements. Call Boxes require a hands-free speakerphone with an LED to indicate status of call.

D. The Call Boxes must allow the programming of a specific location message of the unit. This allows rescue personnel to know the location of the activated Call Box.

E. The Call Boxes are to be located no higher than 48” front reach, or 54” side reach to the center of the button above ground level to ensure conformance with the ADA requirements.

F. The Call Boxes must have a Braille face plate to ensure conformance with the ADA requirements.

G. The Command Center must provide an audible and visual indicator that a Call Box has been activated.

H. The 120vac Power Supply RATH® part # RP7701500 (56-Up Zone) must be capable of supplying power to the Distribution Module.

2.5 MOUNTING

A. The Command Center is to be mounted on a flat wall surface.

B. The Call Boxes are to be wall flush mounted.

2.6 ELECTRICAL REQUIREMENTS

A. The Command Center and Call Boxes (2400 series) are to be powered by the Distribution Module.

B. Distribution Module shall be powered by the RATH® Power Supply. It shall require 120vac power and provide battery backup capable of providing a minimum of 4 hours of electrical backup in case of building power failure.

C. The Base Station shall connect to the Distribution Module with single wire pair (12-16 zone), two wire pairs (28-56 zone) and three wire pairs (76-up zone).

D. Each Call Box shall connect to the Distribution Module with a single wire pair. Wire pairs shall be shielded if near any power runs, otherwise standard pair is acceptable.

1. Cabling for two-way communication system shall meet the applicable requirements for pathway survivability. Cabling installation shall consist of one or more of the following:
   a. UL Listed 2-hour fire-rated cable system – type MI cable, 2-hour fire rated circuit integrity (CI) or listed fire-resistive cable.
   b. 2-hour fire-rated enclosure or protected area.

E. System shall be in compliance with all state and local Electrical Codes.

F. Provide protective covers RATH® 2400-XXXSSPC2.

G. Monitoring of the system integrity is required per NFPA 72, provide RATH® Supervisor Board 2500-XXSPVSR.

2.7 CALLBOX REQUIREMENTS

A. The Call Boxes (RATH® part # 2400-808NSP) shall be an ADA compliant and vandal resistant speakerphone.

B. The Call Boxes shall be hands-free and be a push-button-once to talk system. Once the button has been pushed, the Call Box will call the Base Station. If no answer at the Base Station, it will automatically call a pre-programmed emergency number. The Call Box must be capable of being programmed with up to 2 emergency numbers (either both off-site or Base Station and one off-site).

C. The Call Box shall have location message capability. Call Box must have a minimum 18 second recordable message capability, programmable to play 1 or 2 times. Call Box shall notify called party of the location of the call upon being received at the emergency dispatch center.

D. The Call Box shall be capable of allowing the called party to replay the location message if necessary, to ensure an understanding of the caller location.

E. If system is not attended to 24 hours a day, the Call Box must dial a secondary location outside the building to activate two-way off-site person to person voice communications.

F. Once a call has been made (button pushed), the call can only be terminated by the called party.

G. The Call Box must have a red LED that will light up upon push of the button. The light shall be a solid color when the Call Box is activated and will flash when call has been answered.

H. The Call Box must be capable of being programmed and re-programmed on-site.

I. Standard Call Box features:

1. Two number programming (either both off-site or Base Station and one off-site).
2. Operating temperature of between -40˚F to +150˚F (-40˚ to + 65˚ C).
3. On-site programmable.
4. EEPROM memory to protect programming.

2.8 SIGNAGE

A. System shall consist of a minimum of one 120/277vac edge light sign (part # 7050 or 7050E), a “location” and “instruction” sign (part # 7049) to clearly indicate location of designated area. A tactile sign (part # 7043/7044 or 7087) with raised letter and Braille shall be located at entrance to area.

2.9 GRAPHICS

A. Command Center must include wording identifying the location of each Call Box and light an LED when a particular Call Box has been activated.

B. The Call Box wording must include “Emergency Phone”, International Phone Symbol and raised Braille lettering.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all system components in accordance with manufacturer’s written instructions, in compliance with all applicable codes and standards and in accordance with recognized industry practices.

3.2 COORDINATION

A. It is intended that all installations will be performed in accordance with the Manufacturer's Installation Instructions and as defined herein and within the Subsystem Specifications. If coordination is required beyond local teams, the Owner's Representative may be contacted by the Owner's Representative for guidance.

B. Coordinate all Work to be performed with the General Contractor as necessary for smooth and expedient completion. Ensure critical path to completion where Work specified herein in dependent upon completion of Work by other trades or by Owner. Coordinate with other trades to avoid conflicts where Work in a certain area requires exclusive use of the area for the duration of the Work.

C. Coordinate arrangement and quantity of related assemblies with ceiling space configuration and with other components occupying ceiling space, including structural members, ductwork, electrical raceways, lighting fixtures and other items.

D. Furnish any inserts required for building into concrete, masonry, and other work, to support and attach work of this section. Furnish in ample time to comply with schedule.

3.3 ACCEPTANCE

A. System Warranty shall not start until Acceptance. Acceptance shall be withheld until the following activities have been successfully completed:

1. Acceptance of all submittals.
2. Delivery of final documentation.
3. Successful final test and inspection.
4. Successful operational demonstration test.

B. Successful training and demonstration, including operation of systems using the manuals.

3.4 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup check according to the approved manufacturer's written instructions.

3.5 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct two 4-hour training sessions. Train the Owner's maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

End of Section

Section 27 31 00

VOICE COMMUNICATION EQUIPMENT

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

TO BE ISSUED BY ADDENDA

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. It is the intent of these specifications that the Vendor, Manufacturer and/or its Authorized System Integrator expeditiously furnishes and installs a system complete in every respect and ready to operate. All miscellaneous items and accessories required for such installation, whether or not each such item or accessory as shown on the plans or mentioned in these specifications, shall be furnished and installed.

B. The voice network communications equipment shall be installed as shown on the drawings and as specified herein. The work covered by this section of the specifications includes the furnishing of all labor, equipment, materials and performance of all operations associated with the voice network communications equipment for a fully functional system.

C. The school district has standardized on the Shoretel/Mitel VOIP phone system. The district already has all the core services setup at the network operation center. This includes the virtualized call management server, PRI, mobility router, and Shoregear switch. The core system is version 14 of the Shoretel system and has a current maintenance agreement and ShoreCare support.

1. This contractor shall employ the services of Harbor Networks for installation and maintenance of the system to maintain the district's warranty, maintenance and support agreements.
2. Harbor Networks, point of contact is: Jim McCormack, telephone: 508-652-3062, email: jimm@harbornetworks.com.

D. This contractor shall provide Shoretel/Mitel VOIP phone system as specified herein.

Section 27 41 00

AUDIO-VIDEO COMMUNICATIONS

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. It is the intent of these specifications that the Contractor, Manufacturer and/or it's Authorized System Integrator expeditiously furnishes and installs a system complete in every respect and ready to operate. All miscellaneous items and accessories required for such installation, whether or not each such item or accessory as shown on the plans or mentioned in these specifications, shall be furnished and installed.

B. The audio-video systems shall be installed as shown on the drawings and as specified herein. The work covered by this section of the specifications includes the furnishing of all labor, equipment, materials and performance of all operations associated with the audio-video systems for a fully functional system.

1.4 CODES AND STANDARDS

A. Complete installation shall meet or exceed the latest edition of following standards:

1. TIA-568: Commercial building telecommunications wiring standard and all current addenda.
2. TIA-569: Commercial building standard for telecommunications pathways and spaces.
3. TIA-606: Administration standard for telecommunications infrastructure of commercial buildings.
4. TIA-607: Commercial building grounding and bonding requirements for telecommunications.
5. ANSI, ASTM, UL, NEMA, IEEE and FCC standards as applicable.
6. BICSI Telecommunications Distribution Methods Manual, current edition.

1.5 PROGRAMMING

A. Coordinate and obtain a written approval of system functionality from the Owner prior to programming.

B. Perform a walk-through with the Owner and demonstrate the system functionality.

C. Make any adjustments to system functionality after initial programming if necessary to achieve the desired functionality requested by the Owner. Coordinate all required reprogramming with the Owner as required as part of this contract.

D. Obtain a written final letter of acceptance from the Owner upon completion of system functionality programming and demonstration.

1.6 SUMMARY

A. The Contractor shall furnish and install all equipment including, but not limited to, projectors, projection screens, wiring, connection plates, controllers, signal amplifiers and mounting hardware as shown on the plans, and all other equipment necessary to provide a complete and operating system.

B. Equipment supplied by Contractor shall be considered as meeting these specifications and as the base bid. Any prior approval of an alternate system does not exempt the supplier from meeting the intent of these specifications. If the alternate system fails to provide all the requirements specified in this document, the Contractor shall be responsible for all costs associated with the removal and replacement of said equipment.

1.7 SUBMITTALS

A. Comply with requirements specified in Division 01 and the following:

1. The vendor shall submit certification letter from the manufacturer of submitted equipment certifying that the installer is an authorized and certified installer of the submitted equipment.
2. The vendor shall make all connections at all field devices and at the head-end; and shall make all necessary field adjustments for a fully functional system.

B. Shop Drawings

1. Prior to assembling or installing the system, the Contractor shall provide complete shop drawings which include the following:
   a. List the name of the manufacturer’s local representative and his/her phone number.
   b. Table of contents.
   c. Manufacturer’s parts lists
   d. Product serial numbers
   e. Catalog cut sheets
   f. Installation instructions
   g. Typical wiring diagrams
   h. Drawings showing equipment locations
   i. Manufacturer’s warranty documents

2. All drawings shall be fully dimensioned.

3. Operating License: Submit evidence of application for FCC Radio Station Authorization prior to installing equipment when required for operation of the equipment.

C. As-Built Drawings

1. At the conclusion of the project, the Vendor shall provide “as built” drawings. The “as built” drawings shall be a continuation of the Contractors shop drawings as modified, augmented, and reviewed during the installation, check out and acceptance phases of the project. All drawings shall be fully dimensioned and prepared in DWG format using the latest version of AutoCAD.
2. The as-built drawings shall incorporate all updated system riser diagrams prepared in DWG format using the latest version of AutoCAD.

D. Manuals

1. At the conclusion of the project, the Vendor shall provide copies of the manuals as described herein. Each manual’s contents shall be identified on the cover. The manual shall include names, addresses, and telephone numbers of each system integrator installing equipment and systems and the nearest service representatives for each item of equipment for each system. The manuals shall have a table of contents and labeled sections. The manuals shall include all modifications made during installation, checkout, and acceptance. The manuals shall contain the following:
   a. Hardware Manual
      1) The hardware manual shall describe all equipment furnished including:
      2) General description and specifications
      3) Installation and check out procedures
      4) Equipment layout and electrical schematics to the component level
      5) System layout drawings and schematics
      6) Alignment and calibration procedures
      7) Manufacturers repair parts list indicating sources of supply
   b. Software Manual
      1) The software manual shall describe the functions of all software and shall include all other information necessary to enable proper loading, testing, and operation. The manual shall include:
      2) Definition of terms and functions
         a) Use of system and applications software
         b) Initialization, start up, and shut down
         c) Alarm reports
         d) Reports generation
         e) Data base format and data entry requirements
         f) Directory of all disk files

2. Operators Manual
   a. The operator’s manual shall fully explain all procedures and instructions for the operation of the system including:
      1) Computers and peripherals
      2) System start up and shut down procedures
      3) Use of system, command, and applications software
      4) Recovery and restart procedures
      5) Use of report generator and generation of reports
      6) Data entry
      7) Operator commands
      8) Alarm messages and reprinting formats
      9) System access requirements

3. Maintenance Manual
   a. The maintenance manual shall include descriptions of maintenance for all equipment including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective components.

1.8 QUALITY ASSURANCE

A. The Contractor shall currently maintain a locally run business for a minimum of five years and shall be an authorized distributor of the supplied equipment with full warranty privileges.

B. The Contractor shall maintain at his facility the necessary spare parts in the proper proportion as recommended by the equipment manufacturer to maintain and service the equipment being supplied. This facility shall be available for inspection by the engineer.

C. The supplying Contractor shall have attended the manufacturer's installation and service school.

D. The Contractor shall furnish manufacturer's manuals of the completed system including individual specification sheets, schematics, inter-panel and intra-panel wiring diagrams. In addition, all information necessary for the proper operation of the system must be included. Any bidder using other than the specified equipment must provide this information prior to bidding.

E. As built drawings that include any changes to wiring, wiring designations, junction box labeling and any other pertinent information shall be supplied upon completion of project.

F. Vendors providing equipment installation services shall use adequate numbers of skilled workmen who are certified by the component manufacturer, thoroughly trained and experienced with the necessary technology and systems, and completely familiar with the specified requirements and methods needed for proper performance of work. The system head-end installation, start-up and commissioning shall be by the manufacturer certified vendor.

G. Each vendor is required to provide a certificate from the manufacturer indicating that they hold a current certification for the specified system.

H. Use adequate numbers of skilled workers thoroughly trained and experienced on the necessary crafts and completely familiar with the specified requirements and methods needed for the proper performance of the work of this Section. Contractor is required to provide references of three similar installations completed in the last 12 months.

I. Contractor must provide a project manager who has demonstrated the ability to supervise a project of this magnitude. The Project Manager must be available to attend meetings as required. Acceptance will not be unreasonably withheld.

1.9 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MEDIA CENTER SOUND SYSTEM

A. Basis of design recommendations:

1. Shure UA820 antennas (Qty. 2)
2. Shure UA505 antenna brackets (Qty. 2)
3. Shure UA844 antenna combiner (Qty. 1)
4. Shure ULXS24/58 handheld wireless (Qty. 1)
5. Shure ULXS14/85 lavalier wireless (Qty. 1)
6. RDL CP-2 dual decora plate (Qty. 1)
7. RDL D-CIJ3D line level input plate (Qty. 1)
8. RDL D-J1 mic input plate (Qty. 1)
9. Symmetrix ARC2E Control Wall Plate
10. Denon DN-500C CD/iPod Dock (Qty. 1)
11. RDL ST-MX2 Stereo Mixer (Qty. 1)
12. Lowell TLM600 transformer (Qty. 1)
13. Symmetrix Symnet Radius 12x8 DSP (Qty. 1)
14. Crown CDI 4/600 Amplifier (Qty. 1)
15. JBL Control 226C/T Ceiling Mount Speakers (Qty. 14)
16. Telex SM-2 ALS kit (Qty. 1)
17. Telex RM-S rack kit (Qty. 1)
18. Listen Tech. LA-122 antenna (Qty. 1)
19. Telex BC-102 charger (Qty. 4)
20. MISC. ALS receiver re-chargeable battery (Qty. 8)
21. Linier – FWM18U (Qty. 1)
22. Middle Atlantic vented front door VFD-18 (Qty. 1)
23. Middle Atlantic DWR-RR-18 rack rails (Qty. 1)
24. Middle Atlantic DWR-FK26 fan control (Qty. 1)
25. Middle Atlantic D4 drawer (Qty. 1)
26. Middle Atlantic PDS-620R power sequencer (Qty. 1)
27. Middle Atlantic blank and vent panels (LOT)
28. Shure SM-58 microphone (Qty. 2)
29. Proco M-25 25' mic cord (Qty. 2)
30. On Stage DS-7200QRB mci stand (Qty. 2)

B. Integrate the Owner furnished projection system with the local sound system. Make all final terminations and adjustments for a full working system. Connect audio from projection system into the DSP, then loop out of the DSP and into the mixer.

1. Furnish and install AV wall plates with the following connector and cabling connected to the projector and include signal amplifiers:
   a. HDMI + sound
   b. VGA + 3.5mm audio

2. Provide Extron IN1808 Scaler/switcher in the local sound rack. Connect the Blue Ray HDMI output into the IN1808. The HDMI output of the IN1808 should go to the projector and left and right audio out to the sound system.
   a. Faceplate: Basis of Design RDL CP-2.
   b. AV product: Basis of Design: Extron DTP T UWP 4K 232 D with a corresponding receiver model DTP HDMI 4K 230 RX, install in floor box.
   c. Blue Ray: Basis of Design: Denon - DBT1713UD.

d. Furnish and install Extron TLP Pro 725M wall mount touch panel for video switching and connect to Extron IN 1608 AV switcher.

3. Connect audio from projection system into the DSP, then loop out of the DSP and into the mixer.

C. Furnish and install necessary cables, connectors, or devices necessary for a complete working system.

D. Conduit, back-boxes and electrical power by the Electrical Trade Contractor.

E. Fire Alarm System Interface: All systems shall include a relay to interface to the fire alarm system for sound reinforcement system mute during the activation of the fire alarm system. Provide an Altronix RBST relay and power supply or equal.

F. Public Address System Interface: All systems shall include a relay to interface to the fire alarm system for sound reinforcement system mute during the activation of the fire alarm system. Provide an Altronix RBST relay and power supply or equal.

G. Projection System Interface: Integrate with the projection system to play the audio over the sound system. Provide an additional input to the sound system.

H. Accessories: Provide any distribution amplifiers, transformers, mute-switching, special connectors, cable, modules etc. as required for a complete working system.

I. Impedance and Level Matching: Carefully match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.

J. Part numbers and quantities are for references only. The Contractor shall be responsible for providing all material, equipment and labor for a fully functional system.

2.2 WEIGHT ROOM SOUND SYSTEM

A. Basis of design recommendations:

1. Basis of design recommendations:
2. Shure UA820 antennas (Qty. 2)
3. Shure UA505 antenna brackets (Qty. 2)
4. Shure UA844 antenna combiner (Qty. 1)
5. Shure ULXS24/58 handheld wireless (Qty. 1)
6. Shure ULXS14/85 lavalier wireless (Qty. 1)
7. Symmetrix ARC2E Control Wall Plate
8. Denon DN-500C CD/iPod Dock (Qty. 1)
9. RDL ST-MX2 Stereo Mixer (Qty. 1)
10. Lowell TLM600 transformer (Qty. 1)
11. Symmetrix Symnet Radius 12x8 DSP (Qty. 1)
12. Crown CDI 4/600 Amplifier (Qty. 1)
13. JBL Control 29-AV Wall Mount Speakers (Qty. 4)
14. Telex SM-2 ALS kit (Qty. 1)
15. Telex RM-S rack kit (Qty. 1)
16. Listen Tech. LA-122 antenna (Qty. 1)
17. Telex BC-102 charger (Qty. 4)
18. MISC. ALS receiver re-chargeable battery (Qty. 8)

19. Linier – FWM18U (Qty. 1)
20. Middle Atlantic vented front door VFD-18 (Qty. 1)
21. Middle Atlantic DWR-RR-18 rack rails (Qty. 1)
22. Middle Atlantic DWR-FK26 fan control (Qty. 1)
23. Middle Atlantic D4 drawer (Qty. 1)
24. Middle Atlantic PDS-620R power sequencer (Qty. 1)
25. Middle Atlantic blank and vent panels (LOT)

B. Integrate the Owner furnished projection system with the local sound system. Make all final terminations and adjustments for a full working system. Connect audio from projection system into the DSP, then loop out of the DSP and into the mixer.

1. Furnish and install AV wall plates with the following connector and cabling connected to the projector and include signal amplifiers:
   a. HDMI + sound
   b. VGA + 3.5mm audio

2. Provide Extron IN1808 Scaler/switcher in the local sound rack. Connect the Blue Ray HDMI output into the IN1808. The HDMI output of the IN1808 should go to the projector and left and right audio out to the sound system.
   a. Faceplate: Basis of Design RDL CP-2.
   b. AV product: Basis of Design: Extron DTP T UWP 4K 232 D with a corresponding receiver model DTP HDMI 4K 230 RX, install in floor box.
   c. Blue Ray: Basis of Design: Denon - DBT1713UD.
   d. Furnish and install Extron TLP Pro 725M wall mount touch panel for video switching and connect to Extron IN 1608 AV switcher.

3. Connect audio from projection system into the DSP, then loop out of the DSP and into the mixer.

C. Furnish and install necessary cables, connectors, or devices necessary for a complete working system.

D. Conduit, back-boxes and electrical power by the electrical contractor.

E. Fire Alarm System Interface: All systems shall include a relay to interface to the fire alarm system for sound reinforcement system mute during the activation of the fire alarm system. Provide an Altronix RBST relay and power supply or equal.

F. Public Address System Interface: All systems shall include a relay to interface to the fire alarm system for sound reinforcement system mute during the activation of the fire alarm system. Provide an Altronix RBST relay and power supply or equal.

G. Projection System Interface: Integrate with the projection system to play the audio over the sound system. Provide an additional input to the sound system.

H. Accessories: Provide any distribution amplifiers, transformers, mute-switching, special connectors, cable, modules etc. as required for a complete working system.

I. Impedance and Level Matching: Carefully match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.

J. Part numbers and quantities are for references only. The contractor shall be responsible for providing all material, equipment and labor for a fully functional system.

2.3 WELLNESS CENTER SOUND SYSTEM

A. Basis of design recommendations:

1. Basis of design recommendations:
2. Shure UA820 antennas (Qty. 2)
3. Shure UA505 antenna brackets (Qty. 2)
4. Shure UA844 antenna combiner (Qty. 1)
5. Shure ULXS24/58 handheld wireless (Qty. 1)
6. Shure ULXS14/85 lavalier wireless (Qty. 1)
7. Symmetrix ARC2E Control Wall Plate
8. Denon DN-500C CD/iPod Dock (Qty. 1)
9. RDL ST-MX2 Stereo Mixer (Qty. 1)
10. Lowell TLM600 transformer (Qty. 1)
11. Symmetrix Symnet Radius 12x8 DSP (Qty. 1)
12. Crown CDI 4/600 Amplifier (Qty. 1)
13. JBL Control 29-AV Wall Mount Speakers (Qty. 4)
14. Telex SM-2 ALS kit (Qty. 1)
15. Telex RM-S rack kit (Qty. 1)
16. Listen Tech. LA-122 antenna (Qty. 1)
17. Telex BC-102 charger (Qty. 4)
18. MISC. ALS receiver re-chargeable battery (Qty. 8)
19. Linier – FWM18U (Qty. 1)
20. Middle Atlantic vented front door VFD-18 (Qty. 1)
21. Middle Atlantic DWR-RR-18 rack rails (Qty. 1)
22. Middle Atlantic DWR-FK26 fan control (Qty. 1)
23. Middle Atlantic D4 drawer (Qty. 1)
24. Middle Atlantic PDS-620R power sequencer (Qty. 1)
25. Middle Atlantic blank and vent panels (LOT)

B. Integrate the Owner furnished projection system with the local sound system. Make all final terminations and adjustments for a full working system. Connect audio from projection system into the DSP, then loop out of the DSP and into the mixer.

1. Furnish and install AV wall plates with the following connector and cabling connected to the projector and include signal amplifiers:
   a. HDMI + sound
   b. VGA + 3.5mm audio

2. Provide Extron IN1808 Scaler/switcher in the local sound rack. Connect the Blue Ray HDMI output into the IN1808. The HDMI output of the IN1808 should go to the projector and left and right audio out to the sound system.
   a. Faceplate: Basis of Design RDL CP-2.
   b. AV product: Basis of Design: Extron DTP T UWP 4K 232 D with a corresponding receiver model DTP HDMI 4K 230 RX, install in floor box.
   c. Blue Ray: Basis of Design: Denon - DBT1713UD.
   d. Furnish and install Extron TLP Pro 725M wall mount touch panel for video switching and connect to Extron IN 1608 AV switcher.

3. Connect audio from projection system into the DSP, then loop out of the DSP and into the mixer.

C. Furnish and install necessary cables, connectors, or devices necessary for a complete working system.

D. Conduit, back-boxes and electrical power by the electrical contractor.

E. Fire Alarm System Interface: All systems shall include a relay to interface to the fire alarm system for sound reinforcement system mute during the activation of the fire alarm system. Provide an Altronix RBST relay and power supply or equal.

F. Public Address System Interface: All systems shall include a relay to interface to the fire alarm system for sound reinforcement system mute during the activation of the fire alarm system. Provide an Altronix RBST relay and power supply or equal.

G. Projection System Interface: Integrate with the projection system to play the audio over the sound system. Provide an additional input to the sound system.

H. Accessories: Provide any distribution amplifiers, transformers, mute-switching, special connectors, cable, modules etc. as required for a complete working system.

I. Impedance and Level Matching: Carefully match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.

J. Part numbers and quantities are for references only. The contractor shall be responsible for providing all material, equipment and labor for a fully functional system.

2.4 ADAPTIVE PE

A. Basis of design recommendations:

1. Basis of design recommendations:
2. Shure UA820 antennas (Qty. 2)
3. Shure UA505 antenna brackets (Qty. 2)
4. Shure UA844 antenna combiner (Qty. 1)
5. Shure ULXS24/58 handheld wireless (Qty. 1)
6. Shure ULXS14/85 lavalier wireless (Qty. 1)
7. Symmetrix ARC2E Control Wall Plate
8. Denon DN-500C CD/iPod Dock (Qty. 1)
9. RDL ST-MX2 Stereo Mixer (Qty. 1)
10. Lowell TLM600 transformer (Qty. 1)
11. Symmetrix Symnet Radius 12x8 DSP (Qty. 1)
12. Crown CDI 4/600 Amplifier (Qty. 1)
13. JBL Control 29-AV Wall Mount Speakers (Qty. 4)
14. Telex SM-2 ALS kit (Qty. 1)
15. Telex RM-S rack kit (Qty. 1)
16. Listen Tech. LA-122 antenna (Qty. 1)
17. Telex BC-102 charger (Qty. 4)
18. MISC. ALS receiver re-chargeable battery (Qty. 8)
19. Linier – FWM18U (Qty. 1)
20. Middle Atlantic vented front door VFD-18 (Qty. 1)
21. Middle Atlantic DWR-RR-18 rack rails (Qty. 1)
22. Middle Atlantic DWR-FK26 fan control (Qty. 1)
23. Middle Atlantic D4 drawer (Qty. 1)
24. Middle Atlantic PDS-620R power sequencer (Qty. 1)
25. Middle Atlantic blank and vent panels (LOT)

B. Integrate the Owner furnished projection system with the local sound system. Make all final terminations and adjustments for a full working system. Connect audio from projection system into the DSP, then loop out of the DSP and into the mixer.

1. Furnish and install AV wall plates with the following connector and cabling connected to the projector and include signal amplifiers:
   a. HDMI + sound
   b. VGA + 3.5mm audio

2. Provide Extron IN1808 Scaler/switcher in the local sound rack. Connect the Blue Ray HDMI output into the IN1808. The HDMI output of the IN1808 should go to the projector and left and right audio out to the sound system.
   a. Faceplate: Basis of Design RDL CP-2.
   b. AV product: Basis of Design: Extron DTP T UWP 4K 232 D with a corresponding receiver model DTP HDMI 4K 230 RX, install in floor box.
   c. Blue Ray: Basis of Design: Denon - DBT1713UD.
   d. Furnish and install Extron TLP Pro 725M wall mount touch panel for video switching and connect to Extron IN 1608 AV switcher.

3. Connect audio from projection system into the DSP, then loop out of the DSP and into the mixer.

C. Furnish and install necessary cables, connectors, or devices necessary for a complete working system.

D. Conduit, back-boxes and electrical power by the electrical contractor.

E. Fire Alarm System Interface: All systems shall include a relay to interface to the fire alarm system for sound reinforcement system mute during the activation of the fire alarm system. Provide an Altronix RBST relay and power supply or equal.

F. Public Address System Interface: All systems shall include a relay to interface to the fire alarm system for sound reinforcement system mute during the activation of the fire alarm system. Provide an Altronix RBST relay and power supply or equal.

G. Projection System Interface: Integrate with the projection system to play the audio over the sound system. Provide an additional input to the sound system.

H. Accessories: Provide any distribution amplifiers, transformers, mute-switching, special connectors, cable, modules etc. as required for a complete working system.

I. Impedance and Level Matching: Carefully match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.

J. Part numbers and quantities are for references only. The contractor shall be responsible for providing all material, equipment and labor for a fully functional system.

2.5 AUDIO CABLES AND CONNECTIONS

A. Manufacturers

1. Belden.
2. Canare.
3. Clark.

4. Or approved equal.

B. Audio cables shall be subdivided into three classes: Microphone level circuits, Line level circuits and Speaker level circuits.

C. Microphone level circuits shall be kept at least three inches from any other parallel signal circuits and at least six inches from any parallel AC power circuits.

D. All audio connectors must conform to IEC standards; the convention is pin 1 shield, pin 2 HOT and pin 3 low. If any equipment is supplied wired as pin three hot, it should be changed or adapted to conform to the IEC standard.

E. Ground each audio cable shield at one point and one point only. Terminate shields at the "floating" end with insulating collars or heat shrink. Bare shields or wires in the system will not be acceptable. Connect all electronics grounds to a common point on the equipment rack(s). Ground this point and the rack(s) to the building main service ground point using a ground cable sized for a DC resistance of less than 0.1 ohm.

F. Line level and microphone audio cable shall be 100 percent shielded, 22 gauge twisted pair plenum cable.

G. Speaker level cable shall be unshielded twisted pair, 12 AWG plenum cable.

H. Constant current (70.7 Volt) speaker cable shall be unshielded twisted pair, 18 AWG, plenum cable.

I. Employ multi-conductor cables appropriate to the system and/or equipment to be interfaced.

PART 3 - EXECUTION

3.1 METHODS

A. Install wiring in conduit and raceways except as indicated.

B. Conceal wiring installations where possible.

3.2 INSTALLATION

A. The ceiling cavity is being used as plenum return. Provide plenum rated cables, conduit, backboxes in all plenum rated ceilings, rated walls, penetrations though wall, floors and ceilings and where required by Local, State or Federal Codes.

B. System wiring shall be in accordance with good engineering practices as established by the EIA and NEC. Wiring hall meet all established state and local electrical codes. All wiring shall test free from grounds and shorts. Complete system shall be installed in strict accordance with manufacturer's recommendations.

C. Cable Support: Securely fasten to the permanent building structure where not installed in raceway. Support at regular intervals appropriate to the cable and wire size. Cable and wiring shall not lay loose on ceiling tiles or grids. Install parallel to building lines and follow building structure. Use cable support equipment/hardware recommended by the manufacturer.

D. Cable Pulling: Do not exceed manufacturer's recommended pulling tensions. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between indicated termination, tap, or junction points. Remove and discard cable where damaged during installation and replace it with new cable.

E. Wiring within Enclosures: Bundle, lace, and trim the conductors to terminal points with no excess. Provide and use lacing bars and distribution spools.

F. Identify and tag all cables with permanent type markers to denote location served.

G. Surge Suppressers: Where AC power-operated devices are not protected against voltage transients by integral surge suppressers conforming to UL Standard 1449, install surge suppressers at the device power line terminals.

H. Install and wire equipment in accordance with accepted engineering and installation practices. Only the highest degree of workmanship will be accepted.

I. Arrange equipment to facilitate access for maintenance and working space.

3.3 TERMINATIONS

A. All video wiring shall use BNC connectors suitable for the cable specified. Crimp connectors shall be installed using manufacturers tooling and procedure.

3.4 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup check according to the approved manufacturer's written instructions.

3.5 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct two 4-hour training sessions. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

C. Conduct four 4-hour training sessions. Train teachers and administration personnel on system operation.

End of Section

SECTION 27 41 16

INTEGRATED AUDIOVISUAL SYSTEMS & EQUIPMENT

(Part of the Work of Section 260001 – Electrical Trade Bid)

1.1 GENERAL PROVISIONS

A. The Trade Contractor for this Section shall examine all Drawings and all Sections of the Specification for requirements therein that may affect the Work of this Section, not just those Drawings and Specifications particular to the Work of this Section. The Work of this Section is shown primarily on the following listed Drawings:
   1. Architectural
   2. Electrical
   3. Audiovisual
   4. Theatrical Lighting
   5. Theatrical Rigging

B. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

C. Examine all other Sections of the Specifications for requirements that affect work of this Section whether or not such work is specifically mentioned in this Section.

D. Coordinate work with that of all other trades affecting or affected by work of this Section. Cooperate with such trades to assure the steady progress of all work under the Contract.

1.2 EXAMINATION OF SITE AND DOCUMENTS

A. Bidders are expected to examine and to be thoroughly familiar with all contract documents and with the conditions under which work will be carried out. The Awarding Authority (Owner) will not be responsible for errors, omissions and/or charges for extra work arising from Construction Manager or Electrical Trade Contractor's failure to familiarize themselves with the Contract Documents or existing conditions. By submitting a bid, the Bidder agrees and warrants that he has had the opportunity to examine the site and the Contract Documents, that he is familiar with the conditions and requirements of both and where they require, in any part of the work a given result to be produced, that the Contract Documents are adequate and that he will produce the required results.

1.3 RELATED DOCUMENTS

A. Refer to AV drawings and project architectural, structural and electrical drawings for information related to the work specified herein.

1.4 RELATED WORK SPECIFIED ELSEWHERE

A. Carefully examine all of the Contract Documents for requirements which affect the Work of this Section.

B. Other Specification Sections which directly relate to the Work of this Section include, but are not limited to, the following:
   1. Division 01 - General Requirements
   2. Section 11 06 10 – Stage Rigging and Curtains
   3. Section 11 13 20 – Projection Screens
   4. Section 13 34 26.6 – Press Box
   5. Section 26 50 00 – Theatrical Lighting Control and Fixtures
   6. Division 26 – Electrical; including all Section contained therein
   7. Division 27 - Communication; including all Sections contained therein

1.5 DESCRIPTION OF WORK

A. Furnish and install sound, video and communication systems as shown on drawings and as specified herein, complete with all apparatus, equipment, power supplies, wiring, labor, and services necessary to ensure a complete working system. Verify completeness of equipment listed and correctness of type numbers. Furnish and install supplementary equipment needed to meet system requirements, without claim for added payment.

B. The work includes, but is not limited to, the following:
   1. Submission of shop drawings prior to fabrication.
   2. Verification of dimensions and conditions at the job site.
   3. Installation in accordance with these specifications, manufacturer's recommendations, and all applicable code requirements.
   4. Setup and adjustment of signal processing, system tests and adjustments, written report, demonstration for approval, participation in acceptance tests, and final adjustments as required.
   5. Programming and documenting of all software controlled devices including initial setup of presets in all devices.
   6. Coordination with the Electrical Trade Contractor
   7. Coordination with the Lighting contractor.
   8. Coordination with the Fire Alarm Systems Contractor
   9. Coordination with Tel/Data Contractor and other Low Voltage Contractors
   10. Coordination with Owner’s Audio-Visual Personnel
   11. Coordination with the Owner’s IT department and installers
   12. Performance standards, without claim for additional payment
   13. System documentation.
   14. Instruction of owner's operating personnel.
   15. Maintenance services for one year.
   16. Guarantee.

1.6 SUBMITTALS

A. Provide submittals in accordance with requirements of Division 01 – General Requirements and as detailed herein.

B. Sub Sub-Bid Requirements:
   1. This section 27 4116 Integrated Audiovisual Systems is part of section 27 0000 Communications and is a Sub Sub-Bid to Filed Sub-Bid Section 26 0000 Electrical.

C. Reference Drawings: The Work of this Filed Sub-Bid is shown on the following Reference Drawings. See Section 00 0115 List of Drawings.
   1. AV Series drawings.

D. Qualifications
   1. Bidder shall be an audiovisual systems contractor, normally engaged in the full time business of audiovisual and sound reinforcement system installation. Provide evidence that the bidder has been in business for at least five years prior to bid date and has completed projects of similar size and scope.
   2. References, including names and telephone numbers of individuals who may be contacted, showing satisfactory completion of three or more projects similar in scope and type to that specified herein.
   3. Provide additional evidence of satisfactory completion of audio-visual system installations involving suspended loudspeakers and complex control system integration.
   4. Evidence of ability and affirmation of intent to meet the guarantee and service requirements stated herein.
   5. Qualifications of certified control system programmer who will be working on this project.

E. Each vendor shall include a description of the professional and technical experiences background, qualifications and expertise of the organization's key personnel assigned to this project. The description shall show that bidder possesses the demonstrated skills and experience in specific areas of the project scope. In addition, Bidder shall identify a project manager for the project and shall provide resumes of all personnel who shall be assigned to this project. Bidder shall estimate the percentage of time each individual shall be working on this project

F. First Submittal
   1. Timing: within 45 days of contract award
   2. Qualifications, per requirements listed above.
   3. Conduit size verification
      a. Review and confirm that audiovisual system conduit as shown on the Drawings and where applicable, as built drawings, is sufficient and appropriately sized for system.
      b. Note where conduit system is not sufficient and indicate any additional conduit required for system.
   4. Key project personnel
      a. Provide names, resumes, addresses, mobile and office phone numbers, and e-mail addresses of key project personnel.
   5. Milestone dates
      a. Dates for each Submittal
      b. Shop fabrication complete
      c. Initial equipment ship to site
      d. Start of installation
      e. Second equipment ship to site
      f. Control system programming complete
      g. Field testing
      h. Correction of punch list items
      i. Training

G. Second Submittal
   1. Timing: 90 days before equipment purchase or commencement of wiring.
   2. Before ordering equipment or beginning work, submit list showing quantities and manufacturer and model number for items of equipment to be used in assembling this system, including all items of equipment specified herein. Attach copies of catalog sheets for all items of equipment submitted.
      a. Submit cut sheets in same order as this specification with table of contents, specification paragraph reference and page numbers.
   3. Shop Drawings
      a. Submit all drawings in a single submittal, except if specified otherwise.

b. Submit the following drawings for approval, prior to fabrication and installation:
   1) A block diagram indicating proposed interconnections of all equipment and indicating equipment types and model numbers.
   2) Drawings of loudspeaker mounting arrangements, equipment rack layouts, and receptacle and control plates and boxes.
   3) Plate and panel schedule listing all plates individually with size, mounting condition (surface or flush), back box size and plate finish color.
   4) Drawings of projector mounting arrangements and sight line studies showing proper alignment and dimensions with the projection screen and projection equipment.
   5) Drawings of custom plate and panel details, patch bay layouts and all other necessary wiring diagrams.
   6) Drawings showing cable pull assemblies and schedule complete with all wiring requirements for the project
   7) Drawings of all final assemblies of loudspeaker and LED Wall suspension equipment stamped by a certified structural engineer.
   8) Drawings of anchoring system for loudspeaker suspension.
   9) Submit samples of all panels, custom loudspeaker grills, and loudspeaker cabinet finishes.
   10) List of radio frequencies used by system. Coordinate frequency usage with Owner's designated representative prior to submitting shop drawings.
   11) List of Ethernet devices in system with device name, manufacturer, purpose, MAC address and IP address.

H. Touch Panel
   1. Submit the following for approval prior to programming
   2. First Submittal
      a. Timing: 150 before substantial completion
      b. Line drawings of touch panel layouts button functions listed.
      c. Detailed narrative and demonstration mockup/simulation of all touch panel programming based on design process specified herein.
      d. Three fully designed sample screens for evaluation of graphical look.
   3. Second Submittal
      a. Timing: 120 days before substantial completion
      b. After approval of first touch panel submittal, submit electronic color images of touch panel layouts.

I. Finishes
   1. Obtain Consultant and Architect approval of all panel and furniture finishes prior to fabrication. The Architect will specify exact finishes.

J. Field Supervisor
   1. Before beginning installation, submit the name of the employee who will be the on-site field supervisor through the completion of this project.

K. Copies
   1. Submit a minimum five (5) copies of all required submittals..

1.7 MATERIALS AND EQUIPMENT

A. All systems proposed herein shall meet the best commercial practices of the applicable industries, except where alternatives are noted. Publications of issues of the following standards form a part of this specification:
   1. American Institute of Architects (AIA)

2. Americans with Disabilities Act (ADA)
3. American National Standards Institute (ANSI)
4. Audio Engineering Society (AES)
5. Computer Security Institute (CSI)
6. Federal Communications Commission (FCC)
7. Institute of Cable Engineers (ICEA)
8. Institute of Electrical and Electronic Engineers (IEEE)
9. International Standards Organization (ISO)
10. International Telecommunications Union (ITU)
11. National Association of Broadcasters (NAB)
12. National Electric Code (NEC)
13. National Electrical Manufacturers Association (NEMA)
14. National Fire Protection Association (NFPA)
15. National Institute for Certification in Engineering Technology (NICET)
16. Occupational Safety and Health Administration (OSHA)
17. Society of Motion Picture and Television Engineers (SMPTE)
18. Telecommunications Industry Association (TIA)
19. Underwriters Laboratories (UL)
20. Nationally recognized standards of the various construction trades, as may be applicable.

B. References shall meet the latest edition of that standard

C. Certain items of equipment are specified by manufacturers' type numbers to indicate an acceptable standard of quality and performance. Substitutions of equal equipment beyond the alternatives listed will be permitted only if such equipment is listed in an addendum to this specification. Address requests for listing of substitutions to the Architect. With any request for substitution, include measured data proving the equivalence of the proposed substitute in quality and performance. The Architect shall be the final judge of the validity of the data submitted.

D. Provide only current-model materials and equipment. Do not provide obsolete or discontinued models unless specifically directed to do so in the Equipment section of this specification. Review all materials and equipment immediately prior to installation, and inform the Architect of any obsolete or discontinued items.

1.8 COORDINATION AND CLARIFICATION

A. Refer to the Architect before the bid date for coordination and clarification of any discrepancies among drawings and specifications. Where discrepancies occur and pre-bid instructions have not been obtained, abide by the Architect's reasonable decisions.

B. No extras will be allowed because of the audiovisual system contractors or any installation subcontractor’s misunderstanding as to the amount of work involved or his lack of knowledge of any of the conditions pertaining to the work based on neglect or failure to visit or make a proper examination of the site.

1.9 EXISTING CONDITIONS

A. Verify all existing conditions. Refer to the Architect for coordination and clarification before the bid date of any discrepancies concerning existing conditions. Clarify with the Architect all locations including conduit and cable routings. Where discrepancies occur and pre-bid instructions have not been obtained, abide by the Architect’s reasonable decision.

B. Furnish, install, and terminate all required wire and cable into conduit provided under Division 26.

C. Comply with all requirements regarding the use of cable with respect to spread of fire. Refer to the General Construction drawings for identification of air plenum and other spaces having special cabling requirements. Field-survey the jobsite to determine spaces having special cabling requirements. It is the responsibility of the Audiovisual Contractor to provide wiring that is in compliance with all applicable building codes of the authority(ies) having jurisdiction.

1.10 DELIVERY, STORAGE AND HANDLING

A. All equipment shall be appropriately packed for shipment.

B. All shipping costs to the job site are the responsibility of the Audiovisual Contractor. Determination of the shipping method and company is the responsibility of the Audiovisual Contractor in order to meet the published project schedule.

C. Completed systems shall be shipped FOB inside and in place.

D. Note that drop shipment of equipment to the Owner's site directly from the manufacturer, or other supplier will not be allowed.

E. Upon delivery all materials shall be stored under cover in a clean and dry location. Materials which are damaged during shipping, storage or handling or are otherwise not suitable for installation shall be removed from the job site and replaced, at no additional cost to the Project, with acceptable materials.

1.11 FUNCTIONAL REQUIREMENTS

A. The systems shall provide the following functions:
   1. Auditorium
      a. Reinforcement of speech and music from wired microphone receptacles and wireless microphone systems to listeners in the auditorium through a centralized group of loudspeakers located above the stage.
      b. Supplemental reinforcement of audio signals to listeners in the front of the Auditorium through front-fill loudspeakers installed in the stage apron.
      c. Supplemental reinforcement of audio signals to listeners in the rear and side seating sections of the Auditorium through electronically delayed loudspeakers.
      d. Operator controlled mixing of microphone signals using a mixing console.
      e. Automatic mixing of dedicated wired microphone receptacles and wireless microphone systems (lavalier and handheld) using an automatic mixer system.
      f. Assistive listening system using portable wireless FM receivers.
      g. Reproduction of pre-recorded audio material using a compact disc player unit located unit in a portable equipment rack for use with mixing console.
      h. Reproduction of pre-recorded audio material using a Bluetooth audio receiver with auxiliary analog audio inputs located in the stage equipment rack.
      i. Loudspeaker receptacles and wiring located in and around the stage for portable loudspeakers.
      j. Recording from suspended microphones and main audio system signals using a digital mixer and a hard drive.

k. Cueing of technical personnel using a four-channel production intercom system with wired headsets and connection panels located throughout the Auditorium and related spaces.
l. Reinforcement of announcements from the Auditorium to backstage zones through ceiling mounted loudspeakers.
m. Monitoring of Auditorium activities using a suspended microphone mixed with DSP program feed to backstage zones through ceiling mounted loudspeakers.
n. Monitoring of Auditorium activities using suspended microphone and DSP program feed to lobby zones through ceiling mounted loudspeakers.
o. Reinforcement of alternative audio feeds to lobby loudspeakers through remote panels and patch points.
p. Preset switching and routing for preset event modes and loudspeaker configurations.
q. Overflow audio to and from sound systems in other spaces.
r. Muting of all audio signals in response to fire alarm control signal from fire alarm system.
s. Switching of video signals from a Bluray player, network presenter, and multiple computer inputs for output to a video projector.
t. Remote control of audio DSP system, Bluray player, AV switcher, video projector, and lighting system using touch screen control panels.
u. Reproduction of program material from AV switcher.
v. Flexible routing and patching of audio, video, and network/data signals from panels located throughout the Auditorium to patch panels in the main equipment racks.
w. Automatic muting of video display image in response to fire alarm control signal from fire alarm system.

2. Black Box Theater
   a. Operator controlled mixing of audio signals using a mixing console.
   b. Audio receptacle panels located throughout the theater for use with self-powered portable loudspeakers.
   c. Reproduction of pre-recorded audio material using a playback computer and CD/media player.
   d. Cueing of technical personnel using a production intercom system with wired headsets and connection panels located throughout the space.
   e. Assistive listening system using portable wireless FM receivers.
   f. Multi-channel sound effects playback using a desktop computer and audio interface.
   g. Flexible routing and patching of audio, video, and network/data signals from panels located throughout the Theater to patch panels in the main equipment racks.
   h. Switching of video signals from a Bluray player, network presenter, and multiple computer inputs for output to a video projector.
   i. Remote control of audio DSP system, Bluray player, AV switcher, video projector, and lighting system using touch screen control panels.
   j. Reproduction of program material from AV switcher.
3. Cafeteria System
   a. Reinforcement of speech from wired and microphone receptacles and wireless microphones to listeners in the Cafeteria through a distributed system of pendant and ceiling-mounted loudspeakers.
   b. Automatic mixing of microphone inputs using a digital signal processor.
   c. Reproduction of pre-recorded audio material using playback devices located in an equipment rack, including the following:
      1) compact disc player
      2) iPod interface
      3) Auxiliary source inputs
   d. Control of loudspeaker zones with DSP via rack-mounted and remote volume controls.

e. Reinforcement of announcements through ceiling-mounted loudspeakers.
f. Switching of video signals from a Bluray player, computer inputs and multiple composite video inputs for output to a video projector.
g. Remote control of Bluray player, switcher, video projector, and projection screen.
h. Reproduction of Bluray and computer audio.
i. Reproduction of program material from AV switcher.
j. Assistive listening system using portable wireless FM receivers.
k. Muting of all audio signals in response to fire alarm control signal from fire alarm

4. Band and Chorus Classroom Systems (per room)
   a. Reproduction of pre-recorded music to listeners through wall-mounted left and right loudspeakers.
   b. Reproduction of pre-recorded audio material using a compact disc.
   c. Reproduction of pre-recorded audio material from owner supplied equipment using AV inputs intended for portable devices.
   d. Solid-state recording using digital mixer and hard drive in equipment rack and overhead stereo microphone.
   e. Reinforcement of announcements and monitoring of activities in Auditorium for events via Ethernet audio protocol.
5. Large Group Seminar System
   a. Reinforcement of speech from wired and microphone receptacles and wireless microphones to listeners in the room through a distributed system ceiling-mounted loudspeakers.
   b. Automatic mixing of microphone inputs using a digital signal processor.
   c. Assistive listening system using portable wireless FM receivers.
   d. Switching of video signals from a Bluray player, wireless presentation and computer input for output to a video projector.
   e. Remote control of Bluray player, switcher, video projector, and projection screens.
   f. Reproduction of Bluray and computer audio.
   g. Reproduction of program material from AV switcher.
   h. Muting of all audio signals in response to fire alarm control signal from fire alarm system.
6. Gymnasium System
   a. Reinforcement of speech and music through a distributed system of overhead full-range loudspeakers.
   b. Announcements for games and small speech events using a rolling portable equipment rack.
   c. A hand-held wireless microphone system and wired microphone inputs located in the portable equipment rack.
   d. Manual mixing of portable rack wired and wireless microphone signals using a small mixer located in the portable equipment rack.
   e. Reproduction of pre-recorded audio material using a CD/Media player located in the portable equipment rack.
   f. Program volume control for portable rack CD/Media player located in the portable equipment rack.
   g. Portable equipment rack mixer connections at bleachers and wall panels.
   h. Reproduction of pre-recorded audio material using a wall-mounted Bluetooth audio receiver with auxiliary analog audio inputs.
   i. Control of loudspeaker zones with DSP using remote volume control.
   j. Assistive listening system using portable wireless FM receivers.
   k. Flexible presets that allow loudspeaker zones to be turned off when not in use.
   l. Muting of all audio signals in response to fire alarm control signal from fire alarm system.
7. Athletic Field Sound System

a. Reinforcement of speech and music from wired microphone receptacles and wireless microphone systems to listeners in the bleachers and on the field in front of the bleachers through weatherized loudspeakers mounted on the press box.
b. Operator controlled mixing of audio signals using a portable mixing console.
c. Reproduction of pre-recorded audio material using a wall-mounted Bluetooth audio receiver with auxiliary analog audio inputs.
d. Connection panel for portable media players, portable audio mixer and microphones in the press box.
e. Remote control of audio digital signal processor from the press box.
f. Wiring infrastructure to support portable cameras at filming platform.
g. Assistive listening system using portable wireless FM receivers.
h. Muting of all audio signals in response to fire alarm control signal from fire alarm system.

1.12 ACOUSTICAL PERFORMANCE CRITERIA

A. The overall space-average acoustical frequency response criterion, as measured within the coverage area of the system loudspeakers, is within ±3 dB of a spectrum which is flat from 125 to 2500 Hz and slopes downward thereafter at a rate of 3 dB per octave to 12,500 Hz. Test signals shall be broad-band "pink" noise applied to any system input, measured using 1/3-octave filters centered on ANSI preferred frequencies.

B. Measurements of system performance will be made using a calibrated ANSI or IEC precision sound level meter set for "slow" meter damping and flat response, 4 feet above the floor (seated ear height) within the system coverage area. All interior finishes and furnishings shall be in place, and system gain shall be adjusted to provide levels of at least 70 dB, or 10 dB above background noise levels, whichever is higher, at the measuring locations for these tests.

C. The spatial level uniformity criterion, throughout the sound system coverage areas, is that amplified sound levels shall not vary more than ±2 dB as measured using a test signal consisting of an octave band of "pink" noise centered at 2,000 Hz.

D. To meet the acoustical performance criteria, be responsible for:
1. Use of the equipment specified in the manner specified.
2. Each component's conformance with its manufacturer's published specifications and other requirements as stated herein.
3. Detailed checking of each item of equipment provided, each portion of the installation, and of the complete installation to find and remedy any defects therein.
4. Setting and documenting the adjustments of loudspeakers, equalizers, and other signal-processing equipment, pads, and gain controls, and if so directed by the Architect making the further adjustment of these items, providing additional field-assembled resistive pads and/or resistor-capacitor equalizers.
5. Adjust all equalizers to realize maximum gain and optimal tonal balance from the sound system throughout the audience area.

E. Output level of all program sources arriving at switching or routing equipment shall be within ±0.25 dB of each other as measured at the input to the switcher or router. Provide pads, line amplifiers or other gain control devices as required to achieve this specification.

F. System frequency response shall be 20 - 20 KHz ±3 dB, unless the known, published specifications of a particular piece of mixing, processing, amplification or transducing equipment limit this specification.

G. System signal to noise ratio shall be 60 dB or greater, unless the known, published specifications of a particular piece of mixing, processing, amplification or transducing equipment limit this specification.

1.13 VIDEO PERFORMANCE CRITERIA

A. Provide systems that meet the performance requirements stated in this section. Perform any work required to modify the performance of the system in order to meet these requirements. Perform whatever tests are necessary to confirm compliance with these requirements, before commencement of acceptance testing.

B. Analog Signal Distribution and Cabling
1. The video distribution and cabling system shall meet or exceed the following electrical specifications, measured at any point in the system. Compliance with these specifications shall be determined by introducing a standard video reference signal at points normally used for origination (e.g., camera, DVD player, workstation) and measuring the signal characteristics at points normally serving as destinations (e.g., monitor, projector, DVD player). Note that these are end-to-end performance requirements to be met under all conditions of switcher re-entrance.
2. For purposes of this paragraph, the distribution and cabling system shall include all equipment and cabling normally within the signal path.
3. Frequency Response shall be ±1.5 dB, DC to 100 MHz for computer and component video signals and ±0.5 dB; DC to 5.0 MHz for NTSC encoded composite video signals.
4. Rise time shall be 250 V/microseconds minimum.
5. Crosstalk shall be 45-dB minimum below nominal signal level, unweighted DC to 70 MHz.
6. Signal to Noise Ratio shall be 45-dB minimum, peak noise to RMS signal, unweighted DC to 70 MHz.
7. Signal Gain shall be unity (1.00) terminated into 75 ohms.
8. Line and Field Tilt shall be less than 2 percent.
9. Differential Gain shall be less than 3 percent.
10. Differential Phase shall be less than 3 degrees.
11. Color Timing (where applicable) shall be within 2 degrees at 3.58 MHz.
12. Input Return Loss shall be 40-dB minimum, DC to 70 MHz.
13. Path Length Inequality for Y/C and RGBS cable sets where the signals are not subject to subsequent matrixing or encoding shall be within 12 inches of cable length, or 1.6 nsec.
14. If cable length results in the deterioration of gain and frequency response characteristics and cable compensation equipment are not specified, the system shall be adjusted for best performance. The Audiovisual Contractor shall be able to demonstrate that any inability to meet gain and frequency response specification is due solely to length of cable.

C. Digital Signal Distribution and Cabling
1. Provide digital signal distribution system with the following features:
a. EDID management
b. HDCP compliant
c. HDMI, DVI and DisplayPort signal transport
d. Troubleshooting tools
e. Support for video formats up to and including 1920x1200.
f. Manufacturer-approved cabling

D. Displays (Monitors and Projectors)
1. All displays shall meet manufacturers' published specifications for brightness, contrast, focus, convergence, linearity, distortion, and purity, across the entire range of horizontal and vertical scan frequencies of which the display is capable. In the absence of such

specifications, no convergence, linearity, distortion, or purity errors shall be visible from a viewing distance equal to the image width, and brightness, contrast, and focus shall meet standard performance guidelines.

2. Projectors shall be installed and adjusted so that the resultant images are free from all keystone and barrel distortion and vignetting.
3. Projectors shall exhibit correct color balance, both at black and at peak white, and proper gray scale tracking.
4. All displays shall meet manufacturers' published specifications for horizontal and vertical scan frequency ranges. Where appropriate, adjustments shall be made to allow for automatic scan locking across specified ranges. Image quality specifications discussed above shall be met throughout the horizontal and vertical scan frequency ranges.

1.14 CONTROL SYSTEM CRITERIA

A. General Requirements

1. Provide programming and otherwise configure control system to achieve fully functional system. Coordinate with the Owner. In addition to all other operating controls, ensure that the conditions in this section are met.
2. Provide programming and otherwise configure control system to achieve control as identified below. Sections below do not define panel layouts; refer to drawings.
3. Reliability
    a. Operation shall be 100% reliable. Occasional spurious operation shall not be acceptable.
    b. Every control panel pushbutton shall work as intended when pressed just once. The excuse of "Try it again" shall not be acceptable.
    c. Equipment shall remain operable from its own front panel even when under control from the remote control system. For example, unused outputs on a video router shall be available for manual operation even when other outputs are being switched by the control system.
    d. When a portable control panel is disconnected and re-connected, the panel shall return to normal operation with system status correctly indicated for all functions. If necessary, an initialization pushbutton may be used to force a panel update.
4. Usability
    a. A sub-page or individual function which appears on two different pages shall operate in the same way on each page.
    b. Feedback (tally) shall be accurate 100% of the time. If true feedback cannot be achieved, then feedback generated by the control system must be 100% accurate. If such feedback cannot be accurately generated, then momentary tally (to confirm pushbutton press only) shall be used.
    c. Every function required for proper operation of the audiovisual system shall be under the control of the remote control system, regardless of whether or not that function is in use. For example, a video document camera may have an Internal/External mode function, permitting the display of an external device such as a notebook computer. If the user inadvertently selects External mode, the document camera will be inoperable. The Internal/External mode function shall therefore be under control of the remote control system, so that when the document camera is selected for display, Internal mode is forced.
    d. Functions with an inherent delay (eg. video projector turn-on and warm-up) shall be accompanied by an indication of time remaining until ready (touch panels only). Otherwise, there shall be no perceptible delay either in system response or in status indication.
    e. Ramping functions (such as volume control) shall operate smoothly, with a ramp rate of approximately 5 seconds from minimum to maximum. System response to

ramping commands shall be immediate, and there shall be no perceptible delay in the response of any bargraph indicator.

5. Control Panel Graphics
   a. A conservative graphical standard suitable for a educational application shall be developed and adhered to. This standard shall include the following:
      1) Limited color palette, generally with colored pushbuttons on a light background
      2) No background texture or wallpaper
      3) Limited number of typefaces and type sizes for legends
      4) Pushbuttons properly aligned horizontally and vertically
      5) Consistent and logical use of color - ie. green for normal condition, red for alert.
      6) There shall be no perceptible delay in control panel page flips. Page flips shall be executed without any spurious flashes of unwanted pages or sub-pages.
      7) Control panel pushbuttons shall not be present for functions which will not be required (eg. DVD record) or which are not supported in the application (MCU functions for a video codec without an integral MCU).
      8) In absence of specific direction from Owner or Consultant use Crestron “Neo” Theme or similar as a basis for touch panel graphics.
   b. Develop panel graphics within an independent graphics design program, Adobe PhotoShop or similar, that provides 32-bit color selection and color matching, color and grey scale shading, infinitely-variable light source direction and intensity, and custom typefaces. Import panel graphics thus developed into Crestron VisionTools or AMX TPDesign panel creation software. Do not perform initial graphics development within these Crestron or AMX applications.
6. Other
   a. Configure control system hardware and programming so that the system will recover from a loss of power to any portion of the system or to the system as a whole without operator intervention. Configure so that control system does not lockup during loss of power, and that manual operation of equipment is possible under all conditions.
   b. Provide resistive pull-ups or other means as required to reliably interface to low-voltage remote control systems provided by others, including (but not limited to) projection screens.
   c. Provide other hardware and programming not specifically enumerated herein in order to provide a complete and functioning system that meets the performance requirements identified in this section.

B. Control System and User Interface Development
1. Interview end-users and other individuals as determined by the Owner and his authorized representative to identify requirements for graphical user interfaces on touch screen control panels. Following such interviews, develop conceptual layouts of panel graphics and navigation, and identify functions to be available on each menu page. Adhere to relevant standards or templates as directed. Review with the Owner and his authorized representative before beginning software development.
2. Provide a complete control system. User interface will be through wireless and wired touch panels.
3. Provide the services of a manufacturer-certified programmer. Programming by non-certified personnel is not acceptable.
4. Perform all terminations and wiring required to connect to third-party systems as shown on the Drawings.
5. Auditorium Touch Panel Pages
   a. Splash Screen
   b. Main Page

1) Sources on left hand side of page (fly out "tree menu" and additional text below source name of video format. eg. HDMI, network presenter, Blu-ray
   a) Indication of which source is active
2) Speech and Program volume and mute on right hand side of page
3) Audio-only mode
4) Audio mode selection
   a) Indicate current selection
   b) Automatic mixing (default)
   c) Manual mixing
5) Video mute

c. Preview Monitor source selection
   1) Follow projector (default)
   2) Remote input, network presenter, Blu-ray

d. Blu-Ray Player
   1) Transport controls, disc menu, player menu setup, return, menu navigation

e. Chime
   1) Trigger audience recall chime within DSP.

f. Audio Source Selection
   1) Follow projector (default)
   2) Networked audio input panel Bluetooth
   3) Networked audio input panel analog
   4) Stage rack networked audio input panel Bluetooth
   5) Stage rack networked audio input panel analog

g. Dressing Room Video Monitors
   1) On/Off
   2) Video Mute
   3) Stream selection
      a) Auditorium
      b) Black Box

h. Digital Signal Processor
   1) Muting Presets
      a) Center Cluster loudspeakers on/off
      b) Front-fill loudspeakers on/off
      c) Balcony-fill loudspeakers on/off
   2) Mode Presets
      a) See Functional Diagrams
      b) Do not disturb
   3) Lobby audio controls
      a) Volume
      b) Mute
      c) Source select: auditorium or black box theater
   4) Backstage hallway source select
      a) Auditorium backstage
      b) Black Box front of house
   5) Overflow audio controls
   6) Source selection for classroom monitor feeds
   7) Additional functions per Functional Diagrams

i. Projector Controls
   1) On, off, native, zoom to fit, stretch to fit

j. Lighting
   1) Sixteen presets
   2) Push and hold preset selection button to rename preset with soft keyboard entry

6. Gymnasium Touch Panel Pages
   a. Splash Screen

b. Main Page
   1) Audio Source Selection at left hand side of page
      a) Networked audio input panel Bluetooth
      b) Networked audio input panel analog
   2) Indication of which source is active
   3) Speech and Program volume/mute controls at right hand side of page
c. Digital Signal Processor
   1) Privacy mode (no overflow send)
   2) Do-Not-Disturb mode (no building-wide pages)
   3) Muting Presets
      a) See DSP specifications and Functional Diagrams
   4) Mode Presets
      a) See Functional Diagrams
   5) Additional functions per Functional Diagrams
d. Power Sequencer
   1) Power Up/Down

7. Cafeteria Touch Panel Pages
   a. See Functional Diagrams
8. Athletic Field DSP Control Panel
   a. See Functional Diagrams

1.15 NETWORKING

A. Implement Quality of Service, VLANs, IGMP snooping, STP and other settings on all Ethernet switches as recommended by manufacturer's best practices.

B. Coordinate IP addressing scheme with Owner for connection of AV network to Owner's building network.

1.16 DIAGRAMS AND INSTRUCTION MANUALS

A. Provide draft copies of all required diagrams and instruction manuals on-site for inspection during the demonstration and acceptance testing of the system; submit final copies thereafter.

B. Simplified Line Diagram
   1. Show the essential parts of the completed installation and their functional relations, including all jacks, numbered according to their position on the system patch panels (A, B, etc., for horizontal rows, 1-26 for vertical columns). Mount one copy of the diagram behind clear plastic on the wall near the equipment rack, or as directed. Bind one copy of the diagram into each instruction manual. Reduce the mounted copy to 11" x 17" maximum; insure that it is legible at that size.

C. Receptacle Plans
   1. Provide 11x17 plans showing the location and designation of all receptacles and loudspeakers. Provide separate plans for line/microphone receptacles, loudspeaker receptacles and other receptacles. Indicate jack numbering on plans. Mount one copy and bind other copies into manuals as specified for the line diagram.

D. Operating Manual
   1. Create system specific user manual for the complete system including user instructions for accessing all the system functionality specified in Function Requirements. Manual should describe how to use individual components in their context as part of a larger

system. A compilation of manufacturer's manuals for components does not meet this requirement.

E. Complete Instruction Manuals
1. Provide complete instruction manuals which include the following:
a. Table of contents.
b. List of loose items furnished (microphones, stands, cables, etc.).
c. List of functional requirements.
d. Operating manual (described above).
e. List of settings and adjustments for semi-fixed controls.
f. Manufacturer's sheets of specifications, operating instructions, and service information arranged alphabetically by manufacturer and then by model number, for each item of equipment specified herein.
g. Detailed system wiring diagrams, including cable schedules, DSP functional diagram print-outs and copies of all drawings specified above. Also include all submitted shop drawings to indicate as-built conditions.
h. Provide to Owner and retain a copy of all operating software, if any, and manuals, including custom software.
i. Provide source code for all custom programming created for this project on USB drive.
j. Provide print-out of all touch panel pages.
k. Submit a copy of the manufacturer's standard software and firmware licensing agreement for the Owner's signature. Such license shall grant use of all programs and application software to Owner as defined by the manufacturer's license agreement, but shall protect manufacturer's rights to disclosure of trade secrets contained within such software.
l. Provide five (5) bound copies.

F. Record Drawings
1. Provide greyscale record drawings of as-built conditions in AutoCAD and PDF file format based on Construction Manager's updated base drawings. Drawings shall include at a minimum:
a. Device location plan
b. Functional diagram with wire numbering
c. Panel and rack details.
d. Wiring details
e. Loudspeaker suspension details.
2. Provide USB key with AutoCAD files and one (1) blackline print of drawings.

1.17 INSTRUCTION

A. Provide instruction of Owner's designated operating personnel. Include a minimum of six sessions for a total of twenty-four hours of instruction in the operation, care and maintenance of the installation. Schedule multiple sessions over a one or two year period across both Fall and Spring School Sessions.

B. Schedule instruction at the mutual convenience of the Owner and Audiovisual Contractor, after demonstration and acceptance testing. Provide a digital video recording or otherwise coordinate with the Owner the recording of all instruction sessions and provide a copy of each major session to the Owner.

C. Six months after completion of the installation, the Audiovisual Contractor shall provide a control system review making any minor changes to the control system as the Owner may request based on the configuration at system sign-off.

1.18 WARRANTY AND SERVICE REQUIREMENTS

A. Warranty Period Commencement Date: Effective stating date for Warranty periods is the Date of Substantial Completion for Project as listed under Section 01 12 00 Project Phasing.
   1. Equipment and systems start-up, operation, and use, occurring prior to Project Substantial Completion, will not be considered commencement of warranty period under any terms of this Contract.
   2. Exceptions: Starting dates for warranties prior to the Project Date of Substantial Completion are not permitted, except for the two conditions below:
      a. Warranty requirements specified in individual specification sections explicitly specify that a required warranty or guarantee shall be effective on date of shipment, date of manufacturer, or date of installation.
      b. Warranties for Incomplete work: The effective date for warranty of work which has not been completed prior to the Date of Substantial Completion, shall be effective on the date of the Owner's acceptance of the Work.
      c. This project has two substantial completions, the first for the building and site surrounds, Phase 2. The second for the Parking and Field work, Phase 3 and 4 Refer to PROJECT PHASING REQUIREMENTS Section 01 12 00

B. Guarantee all equipment and installations to be free of faulty workmanship and defective components for a period of one year from date of substantial completion.

C. During this period, replace defective materials and repair faulty workmanship within 24 hours of report of malfunction at no additional cost to the Owner. If specified materials and installations cannot be made good within 24 hours of report of malfunction, provide approved temporary alternate equipment and facilities, complete and operational, within 24 hours of report of malfunction, at no additional cost to the Owner.

D. Maintain a 24-hour-per-day, 365-day-per-year telephone response facility for receipt of service calls.

E. Provide telephone response by qualified support technician within one hour of receiving a service request, and within four hours by the arrival of a technician, if required. Provide this telephone and on-site service during extended business hours, 6:00am - 8:00pm, seven days per week, except for Federal and state holidays.

F. Provide at no additional charge preventive maintenance service for a period of one year after final acceptance of installation. This service shall consist of at least two semi-annual visits to the site for checking and adjustment of equipment.

G. Provide with bid annual cost to extend the preventive maintenance agreement from one to five years after completion.

PART 2 - EQUIPMENT

2.1 WIRING AND CONNECTORS

A. Audio Installed Lines
   1. For cables installed in conduit and entirely within racks, use cable with a foil-shielded pair of stranded #22 AWG conductors, with a stranded shield drain wire. For single pair, use a miniature cable, nominal outside diameter 0.135". Use of multi-pair cable is optional. Provide plenum rated equivalent as required.

a. Belden 8451
b. Liberty 22-1P-EZ
c. West Penn 452

B. Audio Portable Cables
1. For line and microphone level audio umbilical cords use cable with stranded #20 AWG conductors, braided shield, and EPDM rubber jacket.
a. Belden 8412
b. Equal

C. Loudspeaker Wiring
1. Provide unshielded loudspeaker wiring for connection to loudspeakers and loudspeaker receptacles. For lines in rigid conduit or electrical tubing, use stranded or solid conductors. For lines in flexible conduit or electrical tubing and for all wiring to equipment within equipment racks, use only stranded conductors.
2. Use color-coded #12 AWG conductors for all loudspeakers and electronically-delayed loudspeakers except for 70 V ceiling-mounted loudspeakers and loudspeaker receptacles.
a. Belden 8477
b. West Penn 227
c. Approved Equal
3. For all ceiling-mounted loudspeaker wiring using 70.7 Volt lines provide color-coded #18 AWG loudspeaker wiring.
a. Belden 8461
b. West Penn 224
c. Approved Equal
4. Use color-coded #14 AWG conductors for all loudspeaker receptacle wiring.
a. Belden 8473
b. West Penn 226

D. Antenna Wiring
1. Provide coaxial antenna wiring for connections from wireless transmitters and receivers to antenna connection panels.
a. Belden 7810A
b. Equal

E. Category Wiring
1. Provide shielded Category 6 8-conductor twisted pair cable with 23 AWG solid conductors and bandwidth of 250 Mhz for computer data and audiovisual transport wiring.
a. Belden DataTwist series
b. Equal

F. HDBT Wiring
1. Provide shielded Category5e 8-conductor twisted pair cable tested to 350 Mhz and suitable for use with the supplied video distribution system.
a. Crestron DM-CBL-8G
b. Equal

2.2 PATCH PANELS AND ACCESSORIES

A. Microphone and Line Level Patch Panel

1. Provide programmable patch panels to fulfill the requirements shown on the functional diagram. Wire jacks with bridging and normalled-through connections as detailed. Use patch panels which include designation strips with transparent plastic label covers; vertical strips at each side and a three-line (minimum) horizontal strip for each row of jacks. Place jacks close to each other on the patch panel which are shown close to each other on the functional diagram. Locate each bridging jack above the associated normalled-through jack. Use bantam type tip-ring-sleeve jacks with cross-bar palladium or Western Electric #1 gold alloy switching contacts. Both factory-wired and shop-wired patch panels are acceptable. Insulation-displacement terminals are included with the factory-wired patch panels specified herein; other terminal strips or terminal blocks may be substituted, including both solder and screw types. Supply two-foot long red patch cords with nickel-plated plugs. Attach patch cord holder to side of rack or wall near jack field.
    a. Acceptable patch panel:
        1) Audio Accessories WQP-05-P-C-48-N-2
        2) Equal
            a) Quantity: As required
    b. Acceptable patch cord:
        1) Audio Accessories 822A
        2) Equal
            a) Quantity: 40
    c. Acceptable patch cord holder:
        1) Audio Accessories MAXI
        2) Pomona 4408
            a) Quantity: 1

B. Category Patch Panel
1. Provide rack-mount shielded category 6 patch panels. Provide sizes and quantities as required to accommodate patch points per drawings. Provide with one 2-foot patch cable per wired port.
    a. Leviton 4S255-S## w/ 6ASHD-S6A snap-in jacks
    b. Hubbell Equal
    c. L-Com Equal
        1) Quantity: as required per drawings

2.3 INTERFACES

A. AV Input Plate, Networked (AV)
1. Provide Dante-based input/output plate with 2-channel Bluetooth audio input, pairing button, RCA and 3.5 mm stereo analog input, 3.5mm stereo analog output. Provide unit that that receives power and signal via Power Over Ethernet.
    a. Atterotech unD6IO-BT
    b. RDL DDB-BTN44
    c. Equal

B. 2x2 Audio Interface, Networked
1. Provide two input, two output interface to Dante audio network. Provide surface-mounted unit with balanced audio inputs and outputs, selectable microphone/line level input gain and all required power supplies.
    a. Atterotech Dante unDIO2x2
    b. Lectrosonics DNT22
    c. Equal

C. Connectors

1. Connectors from the following manufacturers shall be considered acceptable. Install connectors appropriate for the installed cable and equipment interface.
    a. ADC
    b. Amp
    c. Amphenol
    d. Canare
    e. H.H. Smith
    f. Kings
    g. Neutrik
    h. Pomona
    i. Switchcraft
    j. Trompeter
    k. Approved equal

D. Input Connection Plates
1. All plates are black anodized aluminum with engraved or laser etched white lettering unless otherwise noted.
    a. Wall and ceiling mounted plates visible to public: stainless/brushed aluminum
    b. Wall-mounted plates in stage areas (behind proscenium): black
    c. Wall-mounted plates at catwalk and auditorium overhead areas: black
    d. Wall-mounted plates in Control Room: stainless/brushed aluminum
    e. Floor-Box Mounted plates: white

E. Surface Mount Electrical Gang Boxes
1. Provide surface mount electrical gang boxes for all surface and pipe mount audiovisual devices in project. Coordinate mounting condition and requirements with Electrical Trade Contractor. Provide in black or white as required to match faceplate.
    a. FSR SMWB Series
    b. Levition BKBX Series
    c. Electronic Theatre Controls Equal

F. Press Feed Panels
1. Provide jacks and transformer as shown on Drawings to combine low-impedance line level outputs and match them to inputs of consumer-type (“Hi-Fi”) recording equipment. Provide three-pin receptacles to interface "pro-level” recording equipment to same low-impedance line level outputs. Provide custom assemblies on rack panels and wall plates per Drawings using the following components:
    a. Phono Receptacles
        1) Use female phono ("RCA") panel mounted jacks, as shown below, which are insulated from the mounting panel and which use D-holes or other positive means to prevent jack rotation. Provide sufficient clearance so that inserted plugs do not short to the plate.
    b. Three-Pin Receptacle
        1) Provide three-pin receptacle with black finish, for connection to “pro-level” equipment.
    c. Low-Impedance to High-Impedance Transformer
        1) Mount at signal output jacks as shown to match system line level output to “consumer level” audio equipment.
            a) Jensen JT-10KB-D
            b) Equal

G. Microphone Extension Cable
1. Provide 25-foot long rubber-covered flexible microphone extension cables. Fit each flexible extension cable with black three conductor XLR microphone receptacles. Provide one microphone cable per microphone.

a. Wireworks C25
b. Pro Co M25
c. Approved equal assembly
d. Quantity: As required by number of microphones provided.

H. Isolation Transformer
1. Jensen Transformer JT-11SSP-6M
2. ProCo LOT-1
a. Quantity: As required

I. Dual Line Output Transformer
1. Jensen Transformer DIN-2LO-11FL
2. Equal

J. Dual Two-Way Microphone Splitter
1. Jensen Transformer DIN-MS-2P
2. Equal

K. Low-Impedance to High-Impedance Transformer
1. Mount at signal output jacks as shown to match system line level output to “consumer level” audio equipment.
a. Jensen JT-10KB-D
b. Equal

L. Audio Combiner
1. Provide passive audio combiner network. Provide with power supply as required. Mount in equipment rack.
a. RDL STD series
b. Equal

M. Speaker Level Interface
1. Provide device to convert speaker level to line level for use with paging system. Coordinate with paging system contractor.
a. RDL TX-70A
b. Equal

N. Terminal Blocks
1. Provide DIN-rail mounted terminal blocks where indicated on functional diagrams for microphones and line level lines.
a. Acceptable manufacturers:
1) Wago
2) Entrelec
3) Equal
2. Provide DIN-rail terminal blocks, barrier strips or euro-style blocks for loudspeaker level lines.
1) Wago
2) Entrelec
3) Equal

2.4 RACK EQUIPMENT

A. Rack-Mounted Power Strips

1. For racks without sequenced power control provide vertical power strip as required for rack size and number of circuits. Provide power strip with only circuit breaker protection. No MOV surge protection is required. Provide power strip with NEMA 5-20R (IG) outlets.
   a. Middle Atlantic PD series
   b. Equal

B. Rack Shelf
1. Provide utility rack shelf for mounting of wireless microphone chargers.
   a. Middle Atlantic UTR1
   b. Equal

C. Rack Work Light
1. Provide magnetically mounted gooseneck locally switched LED utility lighting. Connect to unswitched receptacle. Mount in back of equipment rack.
   a. Middle Atlantic LT-GN-WL
   b. Middle Atlantic Equal
   c. Lowell Equal
      1) Quantity: 1 per equipment rack 40 RU and larger

D. 2 Rack Unit Locking Storage Drawer
1. Provide 2 rack space locking rack mounted drawer.
   a. Middle Atlantic D2-LK
   b. Raxxess SDR-2 w/ lock

E. 3 Rack Unit Locking Storage Drawer

1. Provide 3 rack space locking rack mounted drawer.
   a. Middle Atlantic D3-LK
   b. Raxxess SDR-3 w/ lock
   c. Lowell Equal

F. 4 Rack Unit Locking Storage Drawer
1. Provide 4 rack space locking rack mounted drawer.
   a. Middle Atlantic D4-LK
   b. Raxxess SDR-4 w/ lock
   c. Lowell Equal

G. Uninterruptible Power Supply
1. Provide 1000VA minimum rack-mounted UPS system to provide power-surge and power-loss protection to digital signal processor system.
   a. APC SUA1000RM2U
   b. Powerware 5125 1000 RM
   c. Middle Atlantic UPS-1000R

2.5 AUDITORIUM AUDIO INPUT EQUIPMENT

A. Lectern Microphone
1. Provide microphone with shock isolation. Supply microphone with 18-inch long flexible extension tube, stand clamps and foam windscreen. These microphones are intended for general use at lecterns, or on stands for reception of speech or music at distances of approximately 12 to 24 inches from source to microphone. For units without electronic vibration isolation provide additional shock-mount stand adapter. Install one microphone on lectern. Second microphone is provided for portable use.
   a. Countryman Isomax 4RF, M4HP5RF24EB

b. Clock Audio C 35E-RF
c. Shure Equal
1) Quantity: 2

B. Wireless Microphone System
1. Provide all antennas, transmitters, and receivers by a single manufacturer.
2. Provide digital wireless microphone system with AES 256-bit encryption, Dante audio networking, allow up to 16 active transmitters on one 6 Mhz TV channel, switching diversity.
3. Provide all required power supplies and accessories to achieve intent of Drawings.
4. Provide complete with rack-mounting kits.
5. Provide with rack shelves for charging stations.
6. Provide antenna with all required hardware to mount to balcony face and point at stage.
a. Four-Channel Receiver
1) Shure ULXD4Q
2) Sennheiser Equal
3) AKG Equal
a) Quantity: 1
b. Handheld Transmitter
1) Shure ULXD2/SM58
2) Sennheiser Equal
3) AKG Equal
a) Quantity: 4
c. Belt Pack Transmitter
1) Shure ULXD1
2) Sennheiser Equal
3) AKG Equal
a) Quantity: 2
d. Lavalier Microphone - Cardioid
1) Shure MX150/C
2) Sennheiser Equal
3) AKG Equal
a) Quantity: 2
e. Rechargeable Battery
1) Shure SB900
2) Sennheiser Equal
3) AKG Equal
a) Quantity: 6
f. Charging Station
1) Shure SBC800-US
2) Sennheiser Equal
3) AKG Equal
a) Quantity: 1
g. Active Directional Antenna
1) Shure UA874
2) Sennheiser Equal
3) AKG Equal
a) Quantity: 2

C. Vocal Microphone
1. Provide microphone for "close-miked" use by popular, jazz, or folk singers. Provide complete with stand adapters as necessary. Provide with flexible microphone cable as specified above.
a. Shure SM58-LC

b. Electro-Voice N/D 267
c. Audix OM-3xb
d. Sennheiser E835
    1) Quantity: 2

D. Hanging Microphone
1. Provide hanging microphone for general pickup of stage. Provide compete with in-line preamp cable as required.
    a. Shure MX202B/C
    b. Sennheiser Equal
    c. AKG Equal
        1) Quantity: 5

E. Boundary Microphone
1. Provide boundary layer microphone for use as stage floor microphone. Provide low-profile condenser microphone with supercardioid pattern, low-profile and rugged housing. Provide with flexible microphone cable as specified above.
    a. AKG PCC160
    b. Shure Equal
    c. Sennheiser Equal
        1) Quantity: 5

F. Instrument/Vocal Microphone
1. Provide microphone for “close-miked” use with instruments. Provide complete with stand adapters as necessary. Provide with flexible microphone cable as specified above.
    a. Shure Beta 57A
    b. Electro-Voice N/D 478
    c. Audix i5
    d. Sennheiser E840
        1) Quantity: 2

G. Microphone Floor Stand (metal base)
1. Provide an adjustable black microphone stand with 5/8-inch thread and round, weighted metal base.
    a. AKG KM-260/1-black
    b. Atlas MS-12CE
    c. On-Stage MS9201B
        1) Quantity: 4

H. Boom for Floor Stand
1. Provide black, counter-balanced, tiltable boom arm, 32-inches to 34-inches long, compatible with floor stand provided.
    a. AKG KM-211/2-black
    b. Atlas PB-21XE
    c. On-Stage MSA9040TB
        1) Quantity: 4

I. Microphone Floor Stand (tripod base)
1. Provide adjustable black microphone stand with 5/8-inch thread and tripod base. Provide with adjustable-length boom arm.
    a. Atlas TL34-21XE
    b. On-Stage MS7701TB
    c. AKG Equal
        1) Quantity: 4

J. Microphone Table Stand

1. Provide a round base stand with 5/8" thread, round weighted metal base with adjustable height from approximately 8" - 13". Provide stand in black finish.
    a. Atlas DS-7E
    b. AKG Equivalent
    c. On-Stage DS-7200QRB
        1) Quantity: 2

K. Headphone Interface

1. Provide passive stereo 3.5mm to balanced XLR converter with volume control.
    a. Switchcraft #318 Mini Audiostix
    b. Whirlwind Equal
    c. Radial Engineering Equal
        1) Quantity: 2

2.6 AUDITORIUM AUDIO CONTROL AND AMPLIFICATION EQUIPMENT

A. Digital Mixing Console

1. Provide digital audio mixing console with 64x64 Dante interface and a minimum of 16 analog microphone inputs and 2 stereo line input pairs. Provide with a minimum of 6 auxiliary outputs. Provide any additional switches, input cards, etc. necessary for the function of the console as shown on the functional diagrams. Provide with dimmable gooseneck work light and dust cover.
2. Provide console that can connect to both stage box (with pre-amp control) and digital signal processor via Dante.
3. Provide Dante Domain Manager ready units.
    a. Yamaha TF5 w/NY64 card
    b. Soundcraft Equal
    c. Avid Equal
        1) Quantity: 1

B. Bluetooth Receiver

1. Provide phantom-powered Bluetooth receiver with balanced audio output for use with Digital Mixing Console.
    a. Switchcraft 318BT
    b. Equal
        1) Quantity: 1

C. Stereo Direct Box

1. Provide passive stereo direct box with ¼-inch, RCI and 3.5 mm inputs and balanced XLR outputs. Provide with cables to connect to Digital Mixing Console.
    a. Radial Engineering ProAV2
    b. Equal
        1) Quantity: 1

D. Digital Mixing Console Input/Output Box

1. Provide rack-mountable remote I/O device compatible with digital mixing console. Provide device with 16 analog microphone inputs with console-controllable pre-amplifiers, 8 analog line level outputs on 3-pin XLR connectors which connects to the digital mixing console over Digital Audio Network. Provide device which can simultaneously receive 16 channels and send 8 channels of full bit rate digital audio over the single UTP connection. Provide all required input card, switches, etc, to connect to mixing console.

2. Provide Dante Domain Manager ready units.
    a. Yamaha Tio1608-D
    b. Soundcraft Equal
    c. Avid Equal
        1) Quantity: 2

E. Virtual Soundcard Software
1. Provide license for Dante Virtual Soundcard. Install on Owner's Computer.
    a. Quantity: 1

F. Digital Audio Software
1. Provide license for Dante Via. Install on Owner's Computer.
    a. Quantity: 1

G. Digital Signal Processor
1. Provide digital signal processing system with inputs and outputs as shown on drawings, and the following functions. Provide all required devices, accessories, switches and cables to achieve a complete working system.
    a. Feedback suppression
    b. Nine bands of parametric equalization per signal input group
    c. Crossover
    d. Compressor
    e. Digital delay
    f. Signal limiting
    g. Digital audio signal routing
    h. Signal flow as shown on sound system functional drawing(s)
    i. Volume control
    j. Dante digital audio networking
    k. Dante Domain Manager ready
    l. Provide with minimum 25% spare processor headroom after commissioning for future expansion.
        1) BSS London BLU
        2) Biamp Tesira
        3) Symetrix EDGE
        4) QSC Q-Sys
            a) Quantity: 1 complete system, as required

H. Ethernet Switch
1. Provide rack-mounted Ethernet switch(es) with the following minimum properties:
    a. Quality of Service queues: 4
    b. DSCP with strict priority
    c. Port speed: 1 Gbps
    d. Uplink port speed: 10 Gbps
    e. IGMP snooping
    f. IGMP querier
    g. Non-blocking switching fabric
    h. Power over Ethernet
    i. PoE budget: 25% spare capacity at completion of installation
    j. Ports: 25% open at completion of installation
    k. Energy Efficient Ethernet: disabled
    l. DHCP server
    m. VLAN capable
        1) Pakedge
        2) Cisco

3) HP
4) Equal

I. Router
1. Provide router with 2 WAN, 5 LAN, 1 DMZ ports. Provide unit with 1 Gps throughput from WAN to LAN ports. Provide unit capable of 255 VLAN.
2. Provide with rack-mounted hardware.
3. Coordinate connection to school network with Owner's IT personnel.
a. Pakedge K60D
b. Cisco Equal
c. HP Equal
1) Quantity: 1

J. Digital Signal Processor Preset Description
1. Provide digital signal processing settings as described below. Exact determination of digital processor settings is an iterative process and final settings should be determined and documented with careful field measurements. Configure the default mode (with no muting) when master power switch is turned on. Configure so that all inputs are routed to appropriate outputs unless complete routing/rewiring of the internal DSP software devices is required. Presets are described below as parameter changes that do not require a muting and reinitializing of the digital signal processor. Provide access to muting presets through control system if included with project.
a. Presets required:
1) Central Loudspeaker Cluster on/off
2) Front-Fill Loudspeakers on/off
3) Balcony Fill Loudspeakers on/off
4) Backstage Loudspeakers on/off by zone and volume control
5) Audio feed to PTZ camera select
a) Monitor microphone plus console program
b) Main console auxiliary sends
c) Recording mixer
6) Overflow volume
7) Audio feed to Band Classroom select
a) Auditorium
b) Black Box Theater
8) Audio Feed to Chorus Classroom select
a) Auditorium
b) Black Box Theater

K. Power Amplifier, Eight Channel Medium Power
1. Provide eight-channel, power amplifiers with balanced bridging inputs, continuously variable-speed fan(s). Provide amplifier which are 2-rack space units high. Provide amplifier which provide at least 600 watts output (nominal) per channel into 4 ohms and 600 watts output (nominal) per channel into 8 ohms or 70 volts.
a. Crown DCi 8|600
b. QSC CXD8.4Qn
c. Equal
1) Quantity: 1

L. Power Amplifier, Four Channel High Power
1. Provide four-channel, 2-rack unit high power amplifier with balanced bridging inputs, continuously variable-speed fan(s). Provide amplifier which provide at least 1000 watts output (nominal) per channel into 4 ohms and 1200 watts output (nominal) per channel into 8 ohms.

a. Crown DCi 4|1250
b. Lab.gruppen C48:4
c. QSC CXD4.3Q
    1) Quantity: 1

M. Power Amplifier, Eight Channel, Low Power
1. Provide eight-channel, 2-rack unit high power amplifier with balanced bridging inputs, continuously variable-speed fan(s). Provide amplifier which provide at least 300 watts output (nominal) per channel into 4 ohms and 300 watts output (nominal) per channel into 8 ohms or 70 volts.
    a. Crown DCi 8|300
    b. Lab.gruppen C20:8X
    c. QSC Equal
        1) Quantity: 1

2.7 AUDITORIUM EQUIPMENT RACKS AND ACCESSORIES

A. Main Equipment Rack
1. Provide modular rack with bolt-together frame, side panels, locking rear door, and vented, locking front door, which accepts extra panel-mounting angles. Fill in unused rack space with blank solid panels, per industry best practices for air flow. Recess rack rails to allow front doors to close when patch cords are in use. Provide rack, accessories, and filler panels in smooth (not wrinkle) matte black finish. Provide rack with minimum 30-inch depth.
    a. Raxxess GAR-XX-32 Series Assembly
    b. Middle Atlantic WRK-XX32 Series Assembly
    c. Lowell LGR-XX32 Series Assembly
        1) Quantity: 2

B. Main Equipment Rack Cooling Fan
1. Provide cooling fan compatible with and from same manufacturer as equipment rack specified above. Provide with thermostatic automatic fan control.
    a. Middle Atlantic MW-4QFT-FC
    b. Middle Atlantic Equal
    c. Lowell Equal
        1) Quantity: 2

C. Stage Equipment Rack
1. Provide floor-mounted equipment rack with pivoting center section, floor base, and vented, lockable front door. Fill in unused rack space with blank solid panels, per industry best practices for air flow. Provide rack, accessories, and filler panels in smooth (not wrinkle) matte black finish. Provide with thermostatically controlled fan kit.
    a. Middle Atlantic SR-40-32 w/ DWR-FK32, FC-2-215-1CA
    b. Raxxess Equal
    c. Lowell Equal
        1) Quantity: 1

D. Rack Power Wiring
1. Furnish equipment racks with permanently-mounted 3-conductor AC power receptacles with sufficient outlets to meet system needs plus at least 2 spares per rack. Provide raceway configured with separately circuited receptacle groups as required to distribute

load across multiple circuits. Provide whip with plug to match for connection to power outlet box as indicated on the power plan drawings.
- a. Juice Goose CQ-PD1-4, CQ2200, CQ2000 (special order IG version)
- b. Middle Atlantic MPR Series w/ RLM-20IG modules
- c. Lowell Equal
  - 1) Quantity: As required

E. Mix Position Under-Counter Equipment Rack
1. Provide 12-space, laminate castered equipment rack with locking front door to fit under counter in mix position. Provide under with bolt-through casters, and front and rear rack rails. Provide in finish selected from manufacture's standard finishes, per Architect. Provide with active thermostatic ventilation.
   - a. Middle Atlantic BRK-12 w/ RKW-HD, RK-GD12, CFFANKIT-4
   - b. SKB Equal
   - c. Lowell Equal
     - 1) Quantity: 1

F. Portable Equipment Rack
1. Provide portable equipment rack for use of playback equipment by mixing console operator. Provide complete with rack mount power strip and cables as shown on the Drawings.
   - a. SKB 1SKB19-6U
   - b. Technomad (Hardigg) ProRack 6U
   - c. Gatorcases GR-6L
     - 1) Quantity:
       - a) 1 – Playback Rack

G. Portable Input/Output Equipment Rack
1. Provide portable equipment rack for use of stage box equipment. Provide complete with rack mount power strip and cables as shown on the Drawings. Provide with 25 foot extension cord and 25 foot hard-service Ethercon cable for connection to wall.
   - a. SKB 1SKB19-6U
   - b. Technomad (Hardigg) ProRack 6U
   - c. Gatorcases GR-6L
     - 1) Quantity: 1

H. Portable Equipment Rack Power Strip and Light
1. Provide 1 rack unit 15-amp surge-protector and power strip with EMI/RFI filtering, series mode surge protection, and integrated gooseneck rack lighting receptacles.
   - a. Surge-X SX1115-RL w/ (2) LED gooseneck rack lights
   - b. Middle Atlantic Equal
   - c. Furman Equal
     - 1) Quantity: 3

I. System Power Control
1. Provide a relay-controlled power switching system with a master power switch and power-on indicator for the system. Connect the master power switch to control each receptacle in the rack except for one of the spare receptacles. Label unswitched receptacles "UNSWITCHED". Connect power for rack illumination to bypass the system master power switch. Provide a means to cycle the system power amplifiers on sequentially at intervals of approximately one second whenever the power switch is activated.
   - a. Middle Atlantic USC-6R
   - b. Atlas Sound SACR-191

c. Juice Goose CQ1520
1) Quantity: 2

J. System Power Control Remote
1. Provide rack-mounted remote switch for System Power Control.
a. Middle Atlantic S-DEC w/ DECP-1X1
b. Atlas Equal
c. Juice Goose Equal
1) Quantity: 1

K. Rack Lighting
1. Littlite Raklite RL-10-D-LED
2. Middle Atlantic Equal
3. Furman Equal
a. Quantity: 1

2.8 AUDITORIUM LOUDSPEAKER COMPONENTS

A. Loudspeaker Manufacturer
1. All loudspeakers shall be supplied by the same manufacturer, except where that manufacturer does not make one of the specified loudspeakers.

B. Central Cluster Loudspeaker
1. Provide 3-way full range loudspeaker with 15-inch low-frequency drivers, 3-inch voice coil, rotatable waveguide. Provide with all necessary suspension hardware, including supplemental steel as required to create rigging points above loudspeaker. Provide loudspeaker and mounting hardware with black finish.
a. Fulcrum Acoustic DX1565
b. Eastern Acoustic Works QX Equal
c. JBL Equal
1) Quantity: 3

C. Balcony Fill Loudspeaker
1. Provide passive 2-way loudspeaker with 8-inch low frequency transducer, 2-inch voice coil high frequency compression driver, and rotatable waveguide. Provide with all necessary mounting hardware to mount as shown on Drawings. Provide loudspeaker and mounting hardware with finish as directed by architect.
a. Fulcrum Acoustic CX896
b. Eastern Acoustic Works MK8196
c. Equal
1) Quantity: 4

D. Front Fill Loudspeaker
1. Provide compact 2-way loudspeaker with 4-inch concentric driver. Flush-mount in vertical face of stage apron as shown on the Drawings. Provide with grille and bezel in finish per Architect.
a. Tannoy iw4 DC
b. Equal
1) Quantity: 4

E. Loudspeaker Rigging Suspension Equipment
1. Provide loudspeaker rigging for loudspeaker clusters and suspended loudspeakers. Suspend loudspeaker components from brackets and any necessary suspension frames

to minimize total number of ceiling hanging points. Provide with a sufficient number of suspension points for field adjustment of loudspeaker aiming. Provide with color as designated by the Architect. During fabrication and installation verify that adequate clearance from all other hanging components and adequate clearance from structural steel is provided. Provide any additional rigging hardware necessary for the safe and proper installation of these loudspeakers.

2. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:
   a. Ape Rigging
   b. Polar Focus
   c. ATM-Flyware
   d. Approved Contractor-Fabricated Assembly (*Show evidence of successful completion of previous projects)
3. Submit all drawings of the complete final loudspeaker rigging assemblies to a certified structural engineer and obtain approval and stamped copies of the drawings. Drawings should detail all connections from attachment to building structure to loudspeaker.

2.9 AUDITORIUM PLAYBACK EQUIPMENT

A. Compact Disc Player
1. Provide 1U compact disc player with balanced outputs, auxiliary input, Bluetooth audio input, pitch control, and IR remote.
   a. Denon DN-300Z
   b. Tascam Equal
   c. Marantz Equal
      1) Quantity
         a) 1 – portable equipment rack
         b) 1 – stage equipment rack

B. Portable Media Player Compartment
1. Provide rack-mounted compartment with cabling grommets designed for use with portable media players. Provide with Bluetooth Interface (1) pair stereo phone (RCA) connectors with 1/8-inch stereo phone plug to RCA cable for connection to other portable media players. Provide interfaces for connection to separate stereo audio inputs. Provide with integral power/USB outlets mounted on back panel of shelf, per Drawings.
   a. Middle Atlantic SH-DMP-S w/ AV Plate, Networked
   b. Raxxess Equal
   c. Lowell Equal
      1) Quantity: 1 stage equipment rack

2.10 AUDITORIUM ASSISTIVE LISTENING EQUIPMENT

A. Provide wireless assistive listening system consisting of an FM transmitter, an antenna mounted as indicated on drawings, and portable battery-operated receivers with earphones and inductive couplers (the latter for use with hearing aids with "T" switches). Provide frequencies separate and free from interference with other FM systems. Provide all assistive listening system components from the same manufacturer.

B. Transmitter
1. Listen Technologies LT800 with LA-326 rack mounting kit
2. Williams PPA T35 with RPK 006 rack mounting kit

3. Telex Equal
    a. Quantity: 1

C. Transmitter Antenna
1. Listen Technologies LA-122
2. Williams ANT 005 with extension cable
3. Telex Equal
    a. Quantity: 1

2.11 AUDITORIUM RECORDING SYSTEM

A. Shotgun Microphone
1. Provide shotgun microphone.
    a. Sennheiser MKH-416
    b. Shure Equal
    c. AKG Equal
        1) Quantity: 2

B. Microphone Mount
1. Provide pipe mount with shock mount for shotgun microphone to mount to balcony face and point at stage.
    a. Rycote InVision INV-HG mk III w/wall mount
    b. Equal
        1) Quantity: 2

C. Recording Mixer
1. Provide rack-mounted digital audio mixing console with 64x64 Dante interface and a minimum of 16 analog microphone inputs and one stereo line input. Provide with a minimum of 16 configurable analog outputs. Provide unit with USB connection for connection of hard drive for two-track recording and playback or 34-track connection to PC or Mac computer. Provide any additional switches, input cards, etc. necessary for the function of the console as shown on the functional diagrams.
    a. Yamaha TF-Rack w/ NY64-D Dante Card
    b. Allen & Heath Equal
    c. Soundcraft Equal
        1) Quantity: 1

D. Hard Drive
1. Provide 1 TB solid state hard drive approved for use as a recording and playback destination/source with the Recording Mixer. Provide with USB connection to Recording Mixer.
2. Provide with 1 RU rack shelf for mounting in equipment rack.
    a. Transcend StoreJet 1TB
    b. HGST HT0SJA10001BCB
    c. Seagate 1K9AP1-501 1TB
        1) Quantity: 1

E. Headphones
1. Provide monitor headphones for recording mixer.
    a. Sony MDR7506
    b. Sennheiser HD280
    c. AKG K240S
        1) Quantity: 1

2.12 PROGRAM MONITOR/ANNOUNCEMENT SYSTEM

A. Audience Suspended Microphone
1. This microphone is intended for use with the backstage monitor system. Suspend from center of main valance pipe.
2. Provide hard-service cable to connect to MM device on mid-gallery catwalk. Provide cable length such that main valance pipe can fly in and out.
a. Countryman Isomax II-H, M2CP6F50
b. Shure MX202 X/C
c. AKG Equal
d. Sennheiser Equal
1) Quantity: 1

B. Desktop Announce Microphone Console
1. Provide console assembly with gooseneck microphone and weighted base. Provide base with 2 momentary switches for paging zone selection and 6-pin output receptacle. Provide with cable for connection to wall plate in Control Room and at tech table location.
2. Label buttons with black background, white text labels.
a. Clock Audio DMB 2 w/D43 Gooseneck
b. Equal
1) Quantity: 1

C. Desktop Announce Console Cable
1. Provide 15-foot 6-conductor microphone cable with 6-pin male and female XLR connectors.
a. Pro-Co
b. Whirlwind
c. Lex Products
1) Quantity: 2

D. Ceiling Mounted Loudspeaker (S)
1. Provide 70.7-volt loudspeaker/transformer assembly with back box enclosure and paintable grille. Furnish back box enclosure to Electrical Contractor.
a. Atlas FA134T87 w/ FA720-4 Grill and FA97-4 loudspeaker enclosure
b. JBL Equal
c. Soundtube Equal
1) Quantity: per Drawings

E. High-Ceiling Lobby Loudspeaker (LL)
1. Provide compact line array with eight 2-inch drivers, 60-degree vertical coverage, 120-degree horizontal coverage, maximum 4-inches wide, 64-ohm selectable nominal impedance, and finish per architect.
2. Provide with u-bracket and hanging hardware to match loudspeaker.
a. K-Array KK52
b. Equal
1) Quantity: 5

F. 70-Volt Loudspeaker Volume Control
1. Provide wall and rack mounted loudspeaker attenuators for volume control and source selector switch, per details. Coordinate exact electrical device box size requirements with electrical contractor.
2. Wall-Mounted. 10W
a. Atlas AT10
b. Lowell 25LC2

c. Equal
1) Quantity: per Drawings

3. Wall-Mounted, 35W
a. Atlas AT35
b. Lowell 50LVC
c. Equal
1) Quantity: per Drawings

4. Wall-Mounted, 50W
a. Atlas AT35
b. Lowell 50LVC
c. Equal
1) Quantity: per Drawings

5. Wall-Mounted, 100W
a. Atlas AT100
b. Lowell Equal
1) Quantity: per Drawings

6. Source Selector
a. 2-pole, 2-position rotary switch.

2.13 VIDEO MONITOR EQUIPMENT

A. Monitor Camera
1. Provide portable HD box camera with lens. Provide unit with low light sensitivity, H.264 output, power supply, articulating arm and clamp mount.
2. Provide demountable pipe-mounting hardware to allow user to re-locate camera to different places.
a. Marshall CV355-30X-IP, CVM-18 pipe mount
b. Equal
1) Quantity: 2

B. Decoder
1. Provide portable H.264 high-resolution decoder with HDMI output, IP control, Power Over Ethernet, RS-422/485/232 control, and analog audio input. Provide unit compatible with Monitor Camera.
a. Magewell ProConvert H.26X to HDMI
b. Marshall Equal
c. Equal
1) Quantity:
a) Behind displays: 2

C. 43-Inch Display
1. Provide 43-inch class commercial-grade 1920x1080 slim LED lighted flat panel display with IP control recommended for up to 16 hour a day usage.
a. Planar SL4351K
b. Equal
1) Quantity: 2

D. Flat Panel Display Mount, Wall
1. Provide low-profile display wall mount with fine-grade post-installation adjustment. Provide mount with locking mechanism and padlock.
a. Chief Manufacturing MTM1U with padlock.
b. Equal
1) Quantity: 2

2.14 AUDITORIUM PORTABLE LOUDSPEAKERS

A. Active Portable Loudspeaker
1. Provide 2-way loudspeaker with integrated amplifier, 8" low-frequency driver, detented gain control, balanced audio line input and output.
2. Provide each loudspeaker with 25-foot XLR extension cable and 25-foot power cable.
3. Provide units that match Black Box Theater.
a. QSC K8.2
b. Yamaha DXR8
c. JBL Equal
d. DB Technologies Equal
1) Quantity: 4

2.15 PRODUCTION INTERCOM SYSTEM

A. Provide a four-channel production intercom system as shown on the Drawings. Homerun circuits as enumerated to the master station in equipment rack. Connect circuits to master station output channels as shown. Connect power cable to "unswitched" receptacle in equipment rack. Provide single channel belt-packs, headsets and extension cables compatible with the production intercom systems specified below. Provide all equipment from the same manufacturer.

B. Main Station
1. Provide 4-channel production intercom master station. Provide unit capable of supporting up to 55 belt packs / 10 speaker stations. Locate in main equipment rack. Provide with additional power supplies as required.
a. RTS MS-2004
b. Clear-Com MS-704
c. Pro Intercom Equal
1) Quantity: 1

C. Remote Station
1. Provide 4-channel remote station with gooseneck microphone and line-level output for paging microphone connection.
a. Clear-com RM-704 with GM-9 microphone
b. RTS Equal
c. Pro Intercom Equal
1) Quantity: 1

D. 1-Channel Belt-Pack Station
1. RTS BP-1002
2. Clear-Com RS-701
3. Pro Intercom Equal
a. Quantity: 12

E. Headset
1. RTS PH-1
2. Clear-Com CC-300
3. Pro Intercom Equal
a. Quantity: 12

F. Handset
1. RTS HS-6

2. Clear-Com HS-6
3. Pro Intercom Equal
    a. Quantity: 2

G. Intercom Extension Cable

1. Provide twenty-five foot long rubber-covered flexible microphone extension cables. Fit each flexible extension cable with black three conductor XLR microphone receptacles. Provide color-coded shrink-wrap tubing to designate these extension cables separate from the microphone extension cables.
    a. Wireworks C25
    b. Pro Co M25
    c. Whirlwind Equivalent
        1) Quantity: 14

2.16 AUDITORIUM VIDEO SYSTEM INPUT EQUIPMENT

A. Custom Lectern

1. Provide custom lectern with all related audio, video and control equipment securely installed.
2. Provide lectern with the following features:
    a. Standard 19-inch equipment rack mounting
    b. Locking casters
    c. Space for two laptops to sit on work surface
    d. Space for cable management (specified below)
    e. Pull-out drawer for document camera.
    f. Reading light
    g. Clock
    h. Gooseneck microphone
    i. AC power distribution
    j. Locking storage drawer or compartment
    k. Angled mount for touch panel.
3. Wood Species and Finish: per Architect
4. Hardware Finish: per Architect
5. Acceptable Manufacturers:
    a. Middle Atlantic
    b. Miller's Millwork
    c. Marshall Furniture
        1) Quantity: 1

B. Lectern Equipment

1. Integrate specified equipment within lectern specified above. Coordinate installation with Owner's Designated Representative. Secure all equipment neatly within lectern. Provide a means for coiling, storing, and securing excess umbilical cabling within lectern. Provide with all required power supplies and distribution.
2. Cable Management
    a. Provide cable management enclosure mounted in lectern. Provide with cables and cable umbilical as shown on the functional diagram. Label all cables near connector with function. Install in top of lectern as directed by Owner's Designated Representative.
    b. Provide unit with the following:
        1) Two 120V AC Power Outlets
        2) Two powered USB outlets
        3) HDMI cable with retractor

4) UTP network cable with retractor
a) Extron Cable Cubby 1200 assembly
b) Crestron Equal
c) Middle Atlantic Equal

3. Gooseneck Microphone Mount
a. Provide gooseneck microphone mount flush-mounted in top of lectern. Provide with finish chosen from manufacturer's standard options as directed by Architect.
1) FSR T3-MJ-XXX
2) Middle Atlantic Equal
3) AKG Equal
a) Quantity: 1

4. Cables
a. HDMI
1) Extron HDMI Ultra/15
2) Crestron CBL-HD-20
3) AMX Equal
a) Quantity: 4

5. Cable Adapters
a. USB-C to HDMI
1) Extron USBC-HDF/0.5
2) Equal
a) Quantity: 2
b. Displayport to HDMI
1) Extron DPM-HDMIF
2) Crestron Equal
3) AMX Equal
a) Quantity: 1

6. Umbilical Cord
a. Provide 25-foot long umbilical cord for lectern with power, data, and signal cables bundled within a flexible synthetic mesh, clearly labeled and provided with appropriate strain relief. All cables in the umbilical should be designed for hard usage and repeated handling. Use of cables designed for installation in conduit will not be accepted.
1) Quantity: 1

C. Input Panel
1. Provide one-gang digital transport input panel with HDMI connector. Provide unit with support for 4k60 4:4:4 and HDR video signals. Provide device which transports all video signals digitally to the A/V switcher over a single category cable. Provide with faceplate cover to match.
a. Crestron DM-TX-4KZ-100-C-1G-B-T
b. Extron Equal
c. AMX Equal
1) Quantity: 2

D. Blu-ray Player
1. Provide Blu-ray disc player with RS-232 and Ethernet control, DVD support and rack mounting kit.
a. Denon DN-500BD
b. Tascam Equal
c. Marantz Equal
1) Quantity: 1

E. Network Presenter
1. Provide presentation gateway designed to receiver wireless audio and video signals and transmit over HDMI connector. Provide with rack-mount shelf. Coordinate networking with Owner's IT department.
2. May be integrated into Audiovisual Matrix Switcher.
a. Crestron AM-3200
b. Extron ShareLink 250
c. Mersive Solistice
1) Quantity: 1

2.17 AUDITORIUM VIDEO SYSTEM PROCESSING AND CONTROL EQUIPMENT

A. Integrated Audiovisual Matrix Switcher and Controller
1. Provide audiovisual matrix switcher and integrated system control processor with the following properties:
a. Local HDMI inputs: 4
b. Local RGB inputs: 2
c. Remote category cable digital video inputs: 2
d. Local HDMI outputs: 2
e. Remote category cable digital video outputs: 2
f. Bidirectional RS-232 ports: 2
g. Logic inputs: 4
h. IR Outputs: 4
i. Program audio output
j. Ethernet support
k. HDCP key management
l. EDID management
m. Fast HDMI switching
n. CEC signal management
o. HDBT-compatible projector output
p. iPad control license or application credit
1) Crestron DMPS3-4k-350-C
2) Extron DTP CrossPoint 84 IPCP
3) AMX Equal
a) Quantity: 1

2.18 AUDITORIUM VIDEO SYSTEM OUTPUT EQUIPMENT

A. Video Projector
1. Provide solid-state video projector with 14,000 ANSI lumen output (minimum), 1200:1 contrast ratio (minimum), HDBaseT input, and a native aspect ratio of 16:9 and minimum resolution of 1920x1080. Provide projector with zoom lens and recallable zoom, focus and lens shift presets. Verify final throw distance to projection screen, screen size and geometry before ordering lens.
2. Provide case with black or white finish, per Architect.
a. Epson Pro L1755(0) w/ zoom lens
b. Panasonic PT-MZ16KL w/ zoom lens
c. Sony Equal
d. Christie Equal
e. Digital Projection Equal
1) Quantity: 1

B. Flat Panel Monitor, Desktop
   1. Provide 24-inch class, 16:9 native, 1920x1080, LCD monitor for use with switcher specified above.
      a. Samsung
      b. NEC
      c. Sony
      d. Equal
         1) Quantity: 1

2.19 AUDITORIUM CONTROL SYSTEM EQUIPMENT

A. Touch Panel
   1. Provide 10" diagonal touch panel. Provide touch panel that can be controlled and powered by single Category cable. Provide with table-top kit or rack panel as required.
      a. Crestron TSW-1060-B-S
      b. Extron equal
      c. AMX Equal
         1) Quantity:
            a) 1 – Stage Rack
            b) 2 - Portable

B. Touch Panel Mounting Kit
   1. Provide table-top mounting kit for 10" touch panel.
      a. Crestron TSW-1060-TTK-B-S
      b. Extron Equal
      c. AMX Equal
         1) Quantity: 2

C. Cables
   1. Provide serial interface cables, infrared emitters, and line amplifiers as required to control devices shown on the Drawings.

2.20 BLACK BOX THEATER AUDIO PLAYBACK AND MIXING EQUIPMENT

A. Wireless Microphone System

   1. Provide all antennas, transmitters, and receivers by a single manufacturer.
   2. Provide digital wireless microphone system with AES 256-bit encryption, Dante audio networking, allow up to 16 active transmitters on one 6 Mhz TV channel, switching diversity.
   3. Provide all required power supplies and accessories to achieve intent of Drawings.
   4. Provide with half-wave antennae and antenna amplifier mounted at WA devices.
   5. Provide complete with rack-mounting kits.
      a. Dual-Channel Receiver
         1) Shure ULXD4D
         2) Equal
            a) Quantity: 1
      b. Handheld Transmitter
         1) Shure ULXD2/SM58
         2) Equal
            a) Quantity: 2
      c. Rechargeable Battery

1) Shure SB900
2) Equal
a) Quantity: 4

d. Charging Station
1) Shure SBC200-US
2) Equal
a) Quantity: 1

e. Antenna Amplifier
1) Shure UA835
2) Equal
a) Quantity: 2

B. Compact Disc Player
1. Provide 1U compact disc player with balanced outputs, auxiliary input, Bluetooth audio input, pitch control, and IR remote.
a. Denon DN-300Z
b. Tascam Equal
c. Marantz Equal
1) Quantity: 1

C. Virtual Soundcard Software
1. Provide license for Dante Virtual Soundcard. Install on Show Computer.
a. Quantity: 1

D. Show Playback Software
1. Provide MacOS-based multi-channel sound, lighting and video playback software. Install software on Show Computer.
a. Figure 53 QLab Pro Bundle
b. Equal
1) Quantity: 1

E. Show Computer
1. Provide current model computer with minimum 21.5" LCD monitor, 2 TB hard drive, 16 GB RAM, USB connection. Provide with keyboard and mouse.
2. Provide unit compatible with Show Playback Software
a. Apple iMac
b. Equal
1) Quantity: 1

F. Portable Equipment Rack
1. Provide portable equipment rack for use of stage box equipment. Provide complete with rack mount power strip and cables as shown on the Drawings. Provide with 25 foot extension cord and 25 foot hard-service Ethercon cable for connection to wall.
a. SKB 1SKB19-6U
b. Technomad (Hardigg) ProRack 6U
c. Gatorcases GR-6L
1) Quantity: 1

G. USB Audio Interface
1. Provide USB 2.0 audio interface for connection to Show Computer specified above. Provide unit with eight balanced line level audio outputs.
2. Provide with hard service rubber-jacketed cables as required to connect to Audio Mixer specified herein to meet requirements of Functional Diagrams.
a. Focusrite Scarlett 18i20

b. RME Equal
c. Mark of the Unicorn Equal
1) Quantity: 1

H. Bluetooth Receiver

1. Provide phantom-powered Bluetooth receiver with balanced audio output for use with Digital Mixing Console.
a. Switchcraft 318BT
b. Equal
1) Quantity: 1

I. Stereo Direct Box

1. Provide passive stereo direct box with ¼-inch, RCI and 3.5 mm inputs and balanced XLR outputs. Provide with cables to connect to Digital Mixing Console.
a. Radial Engineering ProAV2
b. Equal
1) Quantity: 1

J. Digital Mixing Console

1. Provide digital audio mixing console with 64x64 Dante interface and a minimum of 16 analog microphone inputs and 2 stereo line input pairs. Provide with a minimum of 6 auxiliary outputs. Provide any additional switches, input cards, etc. necessary for the function of the console as shown on the functional diagrams. Mount console in top of portable mixing rack. Provide with dimmable gooseneck work light and dust cover.
a. Yamaha TF1 w/NY64-D card, TF1-Cover
b. Equal
1) Quantity: 1

K. Digital Mixing Console Input/Output Box

1. Provide rack-mountable remote I/O device compatible with digital mixing console. Provide device with 16 analog microphone inputs with console-controllable pre-amplifiers, 8 analog line level outputs on 3-pin XLR connectors which connects to the digital mixing console over Digital Audio Network. Provide device which can simultaneously receive 16 channels and send 8 channels of full bit rate digital audio over the single UTP connection. Provide all required input card, switches, etc, to connect to mixing console.
a. Yamaha Tio1608-D
b. Equal
1) Quantity: 1

L. Digital Signal Processor
1. Provide digital signal processing system with inputs and outputs as shown on drawings, and the following functions. Provide all required devices, accessories, switches and cables to achieve a complete working system.
2. Integrate with Auditorium Digital Signal Processor.
a. Feedback suppression
b. Nine bands of parametric equalization per signal input group
c. Crossover
d. Compressor
e. Digital delay
f. Signal limiting
g. Digital audio signal routing
h. Signal flow as shown on sound system functional drawing(s)
i. Volume control
j. Dante audio networking

k. Provide with 25% spare processing capacity at time of checkout.
1) Biamp Tesira
2) BSS London BLU
3) Symetrix EDGE
4) QSC Q-Sys
a) Quantity: 1 complete system, as required

M. Ethernet Switch

1. Provide rack-mounted Ethernet switch(es) with the following minimum properties:
a. Quality of Service queues: 4
b. DSCP with strict priority
c. Port speed: 1 Gbps
d. Uplink port speed: 10 Gbps
e. IGMP snooping
f. IGMP querier
g. Non-blocking switching fabric
h. Power over Ethernet
i. PoE budget: 25% spare capacity at completion of installation
j. Ports: 25% open at completion of installation
k. Energy Efficient Ethernet: disabled
l. DHCP server
m. VLAN capable
1) Pakedge
2) Cisco
3) HP
4) Equal

2.21 PERFORMING ARTS PROGRAM MONITOR/ANNOUNCEMENT SYSTEM

A. Audience Suspended Microphone
1. This microphone is intended for use with the backstage monitor system.
2. Suspend from pipe grid and connect to grid box, per Functional Diagram.
a. Countryman Isomax II-H, M2CP6F50
b. Shure MX202 X/C
c. AKG Equal
d. Sennheiser Equal
1) Quantity: 1

B. Desktop Announce Microphone Console
1. Provide console assembly with gooseneck microphone and weighted base. Provide base with one momentary switch for push-to-talk and 3-pin output receptacle. Provide with cable for connection to wall plate.
2. Label buttons with black background, white text labels.
a. Clock Audio DMB1 w/D43 Gooseneck
b. Equal
1) Quantity: 1

2.22 BLACK BOX THEATER LOUDSPEAKERS

A. Control Room Monitor Loudspeaker

1. Provide active 2-way compact monitor loudspeakers with 3 inch low-frequency driver and dome tweeter.

2. Provide with short table stand to elevate loudspeakers above mixing console.
    a. Genelec 8010A
    b. M-Audio Studiophile AV 40
    c. Yamaha Equal
    d. JBL Equal
        1) Quantity: 2

B. Active Portable Loudspeaker
1. Provide 2-way loudspeaker with integrated amplifier, 8" low-frequency driver, detented gain control, balanced audio line input and output.
2. Provide each loudspeaker with 25-foot XLR extension cable and 25-foot power cable.
3. Provide each loudspeaker with accessory u-bracket yoke and c-clamp.
    a. QSC K8.2
    b. Yamaha DXR8
    c. JBL Equal
    d. DB Technologies Equal
        1) Quantity: 6

C. Active Portable Subwoofer Loudspeaker
1. Provide low-frequency cardioid subwoofer loudspeaker with dual 12-inch drivers, integrated amplifier, bandpass filer and speaker pole socket.
2. Provide with loudspeaker pole to support Active Portable Full-Range Loudspeakers.
3. Provide each loudspeaker with padded protective cover.
    a. QSC KS212C
    b. Yamaha Equal
    c. JBL Equal
    d. Equal
        1) Quantity: 2

D. Stereo Program Loudspeakers
1. Provide two wall-mounted playback loudspeakers with 10-inch low-frequency drivers. Mount on wall with swivel mount as designated by Architect. Provide complete with all necessary mounting hardware.
2. Finish: Black
    a. QSC AD-S10T
    b. JBL Equal
    c. Tannoy Equal
        1) Quantity: 2

2.23 BLACK BOX THEATER VIDEO EQUIPMENT

A. Loose Equipment
1. Cables
    a. HDMI
        1) Extron HDMI Ultra/15
        2) Crestron CBL-HD-20
            a) Quantity: 4
2. Cable Adapters
    a. USB-C to HDMI
        1) Extron USBC-HDF/0.5
        2) Equal
            a) Quantity: 2
    b. Displayport to HDMI
        1) Extron DPM-HDMIF

2) equal
a) Quantity: 2

B. Input Panel
1. Provide one-gang digital transport input panel with HDMI connector. Provide unit with support for 4k60 4:4:4 and HDR video signals. Provide device which transports all video signals digitally to the A/V switcher over a single category cable. Provide with faceplate cover to match.
a. Crestron DM-TX-4KZ-100-C-1G-B-T
b. Extron Equal
c. AMX Equal
1) Quantity: 1

C. Video Projector
1. Provide video projector with laser phosphor light source, 6,000 ANSI lumen output (minimum), 7500:1 contrast ratio (minimum), 133% vertical lens shift, HDBaseT input, and a native aspect ratio of 16:9 and minimum resolution of 1920x1080. Provide projector with zoom lens and recallable zoom, focus and lens shift presets. Verify final throw distance to projection screen, screen size and geometry before ordering lens.
a. Christie DHD630-GS
b. Epson Pro Equal
c. Sony Equal
1) Quantity: 1

D. Projector Audio Interface
1. Provide 2-channel Dante interface with two unbalanced line-level input for connection to Digital Signal Processor.
2. Integrate into faceplate.
a. RDL DD-BTN44
b. Equal
1) Quantity: 1

E. Video Projector Mounting Hardware
1. Provide all mounting hardware required to mount projector enclosure and projector from wall below control booth. Provide mounting hardware in finish to match projector enclosure.
2. Provide all hardware including, but not limited to:
a. Wall mount
b. Manufacturer:
1) Display Devices
2) Chief
3) Peerless
4) Equal
a) Quantity: 1 complete assembly

2.24 BLACK BOX REMOTE CONTROL SYSTEM EQUIPMENT

A. Button Panel
1. Provide wall-mounted control panel with integrated processor. Provide unit with integrated RS-232, relay and Ethernet ports.
a. Crestron MPC3-302-B
b. Equal
1) Quantity: 1

2.25 BLACK BOX THEATER ASSISTIVE LISTENING EQUIPMENT

A. Provide 216 MHz wireless assistive listening system consisting of an FM transmitter, an antenna mounted as indicated on drawings, and portable battery-operated receivers with earphones and inductive couplers (the latter for use with hearing aids with "T" switches). Provide frequencies separate and free from interference with other FM systems. Provide all assistive listening system components from the same manufacturer.

B. Transmitter
1. Listen Technologies LT800-216-01 with LA-326 rack mounting kit
2. Williams equal rack mounting kit
3. Telex Equal
    a. Quantity: 1

C. Transmitter Antenna
1. Mount antenna to wall at “AL” device.
    a. Listen Technologies LA-124
    b. Williams equal
    c. Telex Equal
        1) Quantity: 1

2.26 MUSIC CLASSROOM SYSTEMS

A. System below is typical. Provide one system each for each room:
1. Band
2. Chorus

B. Recording Microphone
1. Provide suspended microphone with extension cable and isolation mount. Suspend from ceiling for optimum pickup of room activities. Determine final location with Architect. Provide phantom powered condenser microphone with cardioid pickup pattern. Secure rotation with mono-filament fishing line.
    a. Audio-Technica BP4025
    b. Sennheiser MKE 44P w/ shock absorber and extension cable
    c. Shure Equal
        1) Quantity: 1

C. Recording Microphone Suspension Mount
1. Provide hanging accessory to allow suspended microphone to be suspended in its stand attachment using its signal cable. Secure rotation with monofilament line.
    a. Ace Backstage Microphone Hanger Slug #42
    b. On-Stage Equal
    c. AKG Equal
        1) Quantity: 1

D. CD/Media Player
1. Provide 1U compact disc player with balanced outputs, auxiliary input, Bluetooth audio input, and IR remote.
    a. Denon DN-300Z
    b. Tascam Equal
    c. Marantz Equal
        1) Quantity: 1

E. Digital Mixer
1. Provide rack-mounted digital audio mixing console with 64x64 Dante interface and a minimum of 16 analog microphone inputs and one stereo line input. Provide with a minimum of 16 configurable analog outputs. Provide unit with USB connection for connection of hard drive for two-track recording and playback or 34-track connection to PC or Mac computer. Provide any additional switches, input cards, etc. necessary for the function of the console as shown on the functional diagrams.
   a. Yamaha TF-Rack w/ NY64-D Dante Card
   b. Midas Equal
   c. Allen & Heath Equal
      1) Quantity: 1

F. Solid State Hard Drive
1. Provide 1 TB solid state hard drive approved for use as a recording and playback destination/source with the Recording Mixer. Provide with USB connection to Recording Mixer.
2. Provide with 1 RU rack shelf for mounting in equipment rack.
   a. Transcend StoreJet 1TB
   b. HGST HT0SJA10001BCB
   c. Seatgate 1K9AP1-501 1TB
      1) Quantity: 1

G. Integrated Amplifier
1. Provide integrated amplifier, unbalanced inputs, pre-amplifier line-level output and power amplifier with 90 watts continuous (minimum) into 8 ohms. Provide with rack mount hardware.
2. Label unit to correspond to inputs.
   a. Yamaha A-S1100
   b. Marantz PM8006
   c. NAD Equal
      1) Quantity: 1

H. Network Audio Adapter, 2-Channel
1. Provide 2-channel network to audio interface to convert two Dante network audio channels to line level analog audio outputs. Provide with adapters to connect to Integrated Amplifier.
   a. RDL AV-NL2
   b. Dante AVIO Equal
   c. Equal
      1) Quantity: 1

I. Equipment Rack
1. Provide 20 rack space equipment rack with locking 3” casters, locking front door and laminate top. Finish per Architect.
   a. Middle Atlantic MFR-2027-XX
   b. Equal
      1) Quantity: 1

J. Rack Mounted Power Strip
1. Provide 1 rack unit 15-amp surge-protector and power strip with EMI/RFI filtering, series mode surge protection. Provide unit with remote control contact closure.
   a. Surge-X SX1115-RT
   b. Middle Atlantic Equal
   c. Furman Equal

1) Quantity: 1

K. Stereo Loudspeakers

1. Provide two wall-mounted playback loudspeakers with 10-inch low-frequency drivers. Mount on wall with swivel mount as designated by Architect. Provide complete with all necessary mounting hardware. Color per Architect.
   a. QSC AD-S10T w/ X-Mount
   b. JBL Equal
   c. Tannoy Equal
      1) Quantity: 2

2.27 LARGE GROUP SEMINAR EQUIPMENT

A. Wireless Microphone System
1. Provide all antennas, transmitters, and receivers by a single manufacturer.
2. Provide digital wireless microphone system with AES 256-bit encryption, Dante audio networking, allow up to 16 active transmitters on one 6 Mhz TV channel, switching diversity.
3. Provide all required power supplies and accessories to achieve intent of Drawings.
4. Provide with 1/2 –wave antenna mounted to outside of equipment rack.
5. Provide complete with rack-mounting kits.
   a. Dual-Channel Receiver
      1) Shure ULXD4D
      2) Equal
         a) Quantity: 1
   b. Handheld Transmitter
      1) Shure ULXD2/SM58
      2) Equal
         a) Quantity: 2
   c. Belt Pack Transmitter
      1) Shure ULXD1
      2) Sennheiser Equal
      3) AKG Equal
         a) Quantity: 1
   d. Lavalier Microphone - Cardioid
      1) Shure MX150/C
      2) Sennheiser Equal
      3) AKG Equal
         a) Quantity: 1
   e. Rechargeable Battery
      1) Shure SB900
      2) Equal
         a) Quantity: 4
   f. Charging Station
      1) Shure SBC200-US
      2) Equal
         a) Quantity: 1

B. Digital Signal Processor
1. Provide digital signal processing system with inputs and outputs as shown on drawings, and the following functions. Provide all required devices, accessories, switches and cables to achieve a complete working system.
   a. Feedback suppression
   b. Nine bands of parametric equalization per signal input group

c. Crossover
d. Compressor
e. Digital delay
f. Signal limiting
g. Digital audio signal routing
h. Signal flow as shown on sound system functional drawing(s)
i. Volume control
j. Dante Ethernet based digital audio networking
    1) BSS London BLU
    2) Biamp Tesira
    3) Symetrix EDGE
    4) QSC Q-Sys
        a) Quantity: 1 complete system, as required

C. Ethernet Switch
1. Provide SNMP capable, POE+ enabled, gigabit Ethernet switches as required to support a Dante audio network with functionality equivalent to audio network shown on drawings and control system network. Provide Ethernet products compliant with IEEE 802.3.
    a. Cisco
    b. Pakedge
    c. HP
    d. Equal

D. Power Amplifier
1. Provide 4-channel power amplifier with balance bridging inputs and variable speed fan(s). Provide amplifier which is 2-rack space units high. Provide amplifier which supplies at least 300-watts (nominal) per channel at 8-ohms or 70-volts
    a. Crown Dci 4|300
    b. Equal
        1) Quantity: 1

E. Ceiling Loudspeakers
1. Provide low-profile 70-volt ceiling loudspeaker with 6.5 inch driver and 110 degree conical coverage pattern.
    a. JBL Control 26CT
    b. Equal
        1) Quantity: per Drawings

F. Equipment Rack
1. Provide cabinet-mounted, pull-out and pivoting equipment rack with cable management.
    a. Middle Atlantic SRSR-X series
    b. Equal
        1) Quantity: 1

G. Cooling Fan
1. Provide 150 CFM, multi-speed, thermostatic cooling fan designed to mount in side panel of cabinet. Provide unit with maximum noise of 21dBA.
2. Coordinate cabinet cut-out with millwork contractor.
3. Mount fan controller on rack panel.
4. Provide in black or white, per Architect.
    a. AC Infinity AirPlate T9
    b. Equal
        1) Quantity: 1

H. Input Panel

1. Provide one-gang digital transport input panel with HDMI connector. Provide unit with support for 4k60 4:4:4 and HDR video signals. Provide device which transports all video signals digitally to the A/V switcher over a single category cable. Provide with faceplate cover to match.
    a. Crestron DM-TX-4KZ-100-C-1G-B-T
    b. Extron Equal
    c. AMX Equal
        1) Quantity: 1

I. Audiovisual Matrix Switcher and Controller
1. Provide audiovisual matrix switcher with the following properties:
    a. Local HDMI inputs: per Drawings
    b. Remote category cable digital video inputs: per Drawings
    c. Local HDMI outputs: per Drawings
    d. Remote category cable digital video outputs: per Drawings
    e. HD-SDI Inputs: per Drawings
    f. Program audio output
    g. Ethernet support
    h. HDCP key management
    i. EDID management
    j. Fast HDMI switching
    k. CEC signal management
    l. HDBT-compatible projector output
        1) Crestron DMPS3-4K-350-C
        2) Extron DTP Series
        3) AMX Equal
            a) Quantity: 1

J. Button Panel
1. Provide wall-mounted control panel with integrated processor. Provide unit with integrated RS-232, relay and Ethernet ports.
    a. Crestron MPC3-302-W
    b. Equal
        1) Quantity: 1

K. Blu-ray Player
1. Provide Blu-ray disc player with RS-232 and Ethernet control, DVD support and rack mounting kit.
    a. Denon DN-500BD
    b. Equal
        1) Quantity: 1

L. Network Gateway
1. Provide presentation gateway designed to receiver wireless audio and video signals and transmit over HDMI connector. Provide with rack-mount shelf. Coordinate networking with Owner's IT department.
    a. Crestron AM-3200
    b. Extron ShareLink 250
    c. Mersive Solstice Pod
        1) Quantity: 1

M. Video Projector
1. Provide solid-state video projector with 7,000 ANSI lumen output (minimum), 5000:1 contrast ratio (minimum), HDBaseT input, maximum audible noise of 35 dB and a native aspect ratio of 16:9 and minimum resolution of 1920x1080. Provide projector with zoom

lens and recallable zoom, focus and lens shift presets. Verify final throw distance to projection screen, screen size and geometry before ordering lens.

2. Provide with black or white case, per Architect.
    a. Panasonic PT-MZ780 w/zoom lens
    b. Epson PU1007 w/zoom lens
    c. NEC PA804UL
    d. Equal
        1) Quantity: 2

N. Video Projector Mount
1. Provide mount for projector with all required accessories to suspend projector from structure above or projector lift. Provide in black or white, per Architect.
    a. Chief VCMU
    b. Equal
        1) Quantity: 2

O. Assistive Listening System
1. Provide assistive listening system complete with rack-mount transmitter, antenna, signage, belt-pack receivers, headphones and neck loops.
    a. Listen Technologies LS-17-072
    b. Equal
        1) Quantity: 1

2.28 GYMNASIUM AUDIO SOURCE EQUIPMENT

A. Wireless Microphone System
1. Provide all antennas, transmitters, and receivers by a single manufacturer.
2. Provide same manufacturer and product series as all other wireless microphone systems specified in this Section.
3. Provide digital wireless microphone system with AES 256-bit encryption, Dante audio networking, allow up to 16 active transmitters on one 6 Mhz TV channel, switching diversity.
4. Provide dual-channel UHF system which allows simultaneous and independent operation from other wireless systems at the school.
5. Provide all required power supplies and accessories to achieve intent of Drawings.
6. Provide complete with rack-mounting kits.
7. Provide with rack shelves for charging stations.
    a. Two-Channel Receiver
        1) Shure ULXD4D
        2) Sennheiser Equal
        3) AKG Equal
            a) Quantity: 1
    b. Handheld Transmitter
        1) Shure ULXD2/SM58
        2) Sennheiser Equal
        3) AKG Equal
            a) Quantity: 2
    c. Rechargeable Battery
        1) Shure SB900A
        2) Sennheiser Equal
        3) AKG Equal
            a) Quantity: 2
    d. Charging Station with Power Supply
        1) Shure SBC200-US

2) Sennheiser Equal
3) AKG Equal
a) Quantity: 1

B. Vocal Microphone
1. Provide microphone for "close-miked" use by presenters and performers. Provide complete with stand adapters as necessary. Provide with flexible microphone cable as specified above.
a. Shure SM58-LC
b. Electro-Voice N/D 267
c. Audix OM-3xb
d. Sennheiser E835
1) Quantity: 2

C. Microphone Floor Stand (tripod base)
1. Provide adjustable black microphone stand with 5/8-inch thread and tripod base. Provide with adjustable-length boom arm.
a. Atlas TL34-21XE
b. On-Stage MS7701TB
1) Quantity: 2

D. Microphone Table Stand
1. Provide a round base stand with 5/8-inch thread, round weighted metal base with adjustable height from approximately 8" - 13". Provide stand in black finish.
a. Atlas DS-7E
b. AKG Equivalent
c. On-Stage DS-7200QRB
1) Quantity: 2

E. CD/Media Player
1. Provide 1U compact disc player with balanced outputs, auxiliary input, Bluetooth audio input, pitch control, and IR remote.
a. Denon DN-300Z
b. Equal
1) Quantity: 1

F. Line Level Audio Volume Control
1. Provide line level audio volume control assembly.
a. RDL ST-VCA3 w/ D-RLC10K mounted in rack panel
b. Equal assembly
1) Quantity: 1

2.29 GYMNASIUM AUDIO CONTROL AND AMPLIFICATION EQUIPMENT

A. 8-Channel Mixer
1. Provide rack-mounted mixer with at least 8 microphone/line inputs. Provide with rack-mounting kit. Mount in rolling portable equipment rack.
a. Shure SCM800
b. Equal
1) Quantity: 1

B. Digital Signal Processor

1. Provide digital signal processing system with inputs and outputs as shown on drawings, and the following functions. Provide all required devices, accessories, switches and cables to achieve a complete working system. Provide sufficient processing components to program specified processing capabilities without exceeding 80% of total system processing resources.
    a. Feedback suppression
    b. Nine bands of parametric equalization per signal input group
    c. Crossover
    d. Compressor
    e. Digital delay
    f. Signal limiting
    g. Digital audio signal routing
    h. Signal flow as shown on sound system functional drawing(s)
    i. Volume control
    j. Dante Ethernet based digital audio networking
    k. Provide with 25% spare processing capacity at time of checkout.
        1) BSS London BLU
        2) Biamp Tesira
        3) Symetrix EDGE
        4) QSC Q-Sys
            a) Quantity: 1 complete system, as required

C. Digital Signal Processor Preset Description
1. Provide digital signal processing settings as described below. Exact determination of digital processor settings is an iterative process and final settings should be determined and documented with careful field measurements. Configure the default mode (with no muting) when master power switch is turned on. Configure so that all inputs are routed to appropriate outputs unless complete routing/rewiring of the internal DSP software devices is required. Presets are described below as parameter changes that do not require a muting and reinitializing of the digital signal processor.
    a. Muting Presets:
        1) North Bleacher Loudspeakers on/off
        2) South Bleacher Loudspeakers on/off
        3) West Court Loudspeakers on/off
        4) East Court Loudspeakers on/off
        5) Far East Court Loudspeakers on/off

D. Digital Signal Processor Volume Control
1. Provide multi-station volume control compatible with Digital Signal Processor.
    a. Symetrix ARC-K1
    b. Attero Tech Axon C1
    c. BSS Contrio EC-V
    d. QSC Equal
        1) Quantity: 1

E. Volume Control Protection
1. Provide clear polycarbonate vandalism protection for Digital Signal Processor Volume Control. Provide in size as required to fit volume control. Provide with custom label, per Drawings. Provide with custom faceplate to mount Volume Control. Label color per Architect.
    a. STI Universal Stopper
    b. Equal
        1) Quantity: 1 per Volume Control in Gymnasium

F. DSP Control Panel

1. Provide 5-inch rack-mount touch panel controller for control of Digital Signal Processor.
    a. Biamp TEC-X
    b. QSC TSC-55w-G2
    c. Symetrix T-5 Gen2
    d. AMX Equal
        1) Quantity: 1

G. Ethernet Switch
1. Provide SNMP capable, POE enabled, managed, gigabit Ethernet switches as required to support a Dante audio network with functionality equivalent to audio network shown on drawings and control system network. Provide Ethernet products compliant with IEEE 802.3.
2. Provide switch with multi-mode fiber interfaces to create network topology, per Drawings.
    a. Pakedge
    b. Cisco
    c. HP
    d. Equal
        1) Quantity: 1

H. Power Amplifier, 8-Channel
1. Provide eight-channel power amplifier with balanced bridging inputs, continuously variable-speed fan(s). Provide amplifier which are 2-rack space units high. Provide amplifier which provide at least 600 watts output (nominal) per channel into 4 ohms and 600 watts output (nominal) per channel into 8 ohms or 70 volts.
    a. Crown DCi 8|600
    b. QSC CXD8.4Qn
    c. Equal
        1) Quantity: 1

I. Power Amplifier 4-Channel
1. Provide four-channel power amplifier with balanced bridging inputs and variable-speed fan(s). Provide amplifier which is 2-rack space units high. Provide amplifier which supplies at least 300-watts (nominal) per channel at 8-ohms and at least 500-watts (nominal) per channel at 4-ohms.
    a. Crown DCi 4|600
    b. Lab.gruppen C28:4
    c. QSC CXD4.2Q
        1) Quantity: 1

2.30 GYMNASIUM EQUIPMENT RACKS AND ACCESSORIES

A. Main Equipment Rack
1. Provide floor-mounted equipment rack with pivoting center section, floor base, and vented, lockable front door. Fill in unused rack space with blank solid panels, per industry best practices for air flow. Provide rack, accessories, and filler panels in smooth (not wrinkle) matte black finish. Provide with thermostatically controlled fan kit.
    a. Middle Atlantic SR-40-32 w/ DWR-FK32, FC-2-215-1CA
    b. Equal
        1) Quantity: 1

B. Rolling Portable Equipment Rack
1. Provide 14-rack unit rolling portable equipment case for wireless microphone system, microphone mixer, CD player, portable media player interfaces, rack drawer and power

and light units. Provide unit with 4-inch casters, front and rear racks rails, wood top and metal front and rear doors. Provide complete with rack-mounted power strip and at least two (2) spare power receptacles. Provide 25-foot balanced audio cables for connecting equipment outputs to input receptacles.

a. Middle Atlantic PTRK-14MDK
b. Equal
    1) Quantity: 1

C. Rack Power Wiring

1. Furnish equipment racks with permanently-mounted 3-conductor AC power receptacles with sufficient outlets to meet system needs plus at least 2 spares per rack. Provide raceway configured with separately circuited receptacle groups as required to distribute load across multiple circuits. Provide whip with plug to match for connection to power outlet box as indicated on the power plan drawings.
    a. Juice Goose CQ-PD1-4, CQ2200, CQ2000
    b. Middle Atlantic MPR Series w/ RLM-20 modules
    c. Lowell Equal
        1) Quantity: As required

D. System Power Control

1. Provide a relay-controlled power switching system with a master power switch and power-on indicator for the system. Connect the master power switch to control each receptacle in the rack except for one of the spare receptacles. Label unswitched receptacles "UNSWITCHED". Connect power for rack illumination to bypass the system master power switch. Provide a means to cycle the system power amplifiers on sequentially at intervals of approximately one second whenever the power switch is activated.
    a. Middle Atlantic USC-6R
    b. Atlas Sound SACR-191
    c. Juice Goose CQ1520
        1) Quantity: 1

E. Rack Work Light

1. Provide magnetically mounted gooseneck locally switched LED utility lighting. Connect to unswitched receptacle. Mount in back of equipment racks.
    a. Middle Atlantic LT-GN-WL
    b. Equal
        1) Quantity: 1

2.31 GYMNASIUM LOUDSPEAKER COMPONENTS

A. Gym Loudspeaker

1. Provide passive 2-way loudspeaker with 12-inch low frequency transducer, 2-inch voice coil high frequency compression driver, and rotatable waveguide. Provide with all necessary mounting hardware. Provide loudspeaker and hanging hardware in finish per Architect.
    a. EAW VFR129i
    b. JBL AC299
    c. Electro-Voice EVF-S/12
        1) Quantity: 20

B. Loudspeaker Rigging and Suspension Equipment

1. Provide contractor fabricated and designed loudspeaker rigging for loudspeaker clusters and suspended loudspeakers. Suspend loudspeaker components from brackets and any

necessary suspension frames to minimize total number of ceiling hanging points. Provide with a sufficient number of suspension points for field adjustment of loudspeaker aiming. Provide with color as designated by the Architect. During fabrication and installation verify that adequate clearance from all other hanging components and adequate clearance from structural steel is provided. Provide any additional rigging hardware necessary for the safe and proper installation of these loudspeakers.

2. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:
   a. Ape Rigging
   b. Polar Focus
   c. ATM-Flyware
   d. Approved Contractor-Fabricated Assembly (*Show evidence of successful completion of previous projects)
3. Submit all drawings of the complete final loudspeaker rigging assemblies to a certified structural engineer and obtain approval and stamped copies of the drawings. Drawings should detail all connections from attachment to building structure to loudspeaker.

2.32 GYMNASIUM ASSISTIVE LISTENING EQUIPMENT

A. Provide wireless assistive listening system consisting of an FM transmitter, an antenna mounted as indicated on drawings, and portable battery-operated receivers with earphones and inductive couplers (the latter for use with hearing aids with "T" switches). Provide frequencies separate and free from interference with other FM systems. Provide all assistive listening system components from the same manufacturer. Provide products that work in same frequency band as and are compatible with all other assistive listening systems and equipment specified in this Section.

B. Transmitter
   1. Listen Technologies LT800 with LA-326 rack mounting kit
   2. Williams PPA T55 w/ RPK 006 or RPK 005 rack mounting kit as required per drawings
   3. Telex Equal
      a. Quantity: 1

C. Transmitter Antenna
   1. Provide coaxial di-pole antenna suitable for use with FM transmitter.
      a. Listen Technologies LA-116
      b. Williams ANT 005 with extension cable
         1) Quantity: 1

2.33 CAFETERIA AUDIO EQUIPMENT

A. Wireless Microphone System
   1. Provide all antennas, transmitters, and receivers by a single manufacturer.
   2. Provide digital wireless microphone system with AES 256-bit encryption, Dante audio networking, allow up to 16 active transmitters on one 6 Mhz TV channel, switching diversity.
   3. Provide all required power supplies and accessories to achieve intent of Drawings.
   4. Provide ½ wave antenna for receiver in rolling rack.
   5. Provide complete with rack-mounting kits.
      a. Dual-Channel Receiver
         1) Shure ULXD4D

2) Equal
a) Quantity: 2

b. Handheld Transmitter
1) Shure ULXD2/SM58
2) Equal
a) Quantity: 4

c. Rechargeable Battery
1) Shure SB900
2) Equal
a) Quantity: 6

d. Charging Station
1) Shure SBC800-US
2) Equal
a) Quantity: 1

e. Wall-Mount Antenna
1) Shure UA864US
2) Equal
a) Quantity: 2

B. Digital Signal Processor
1. Provide digital signal processing system with inputs and outputs as shown on drawings, and the following functions. Provide all required devices, accessories, switches and cables to achieve a complete working system.
a. Feedback suppression
b. Nine bands of parametric equalization per signal input group
c. Crossover
d. Compressor
e. Digital delay
f. Signal limiting
g. Digital audio signal routing
h. Signal flow as shown on sound system functional drawing(s)
i. Volume control
j. Dante Ethernet-based digital audio networking
k. Provide processor with 25% processor headroom at checkout
1) BSS London BLU
2) Biamp Tesira
3) Symetrix EDGE
4) QSC Q-Sys
a) Quantity: 1 complete system, as required

C. Digital Signal Processor Preset Description
1. Provide digital signal processing settings as described below. Exact determination of digital processor settings is an iterative process and final settings should be determined and documented with careful field measurements. Configure the default mode (with no muting) when master power switch is turned on. Configure so that all inputs are routed to appropriate outputs unless complete routing/rewiring of the internal DSP software devices is required. Presets are described below as parameter changes that do not require a muting and reinitializing of the digital signal processor.
a. Loudspeaker mute by zone
b. Microphone volume control
c. Program volume control

D. Ethernet Switch

1. Provide SNMP capable, POE+ enabled, gigabit Ethernet switches as required to support a Dante audio network with functionality equivalent to audio network shown on drawings and control system network. Provide Ethernet products compliant with IEEE 802.3.
    a. Cisco
    b. Pakedge
    c. HP
    d. Equal

E. CD/Media Player
1. Provide 1U compact disc player with balanced outputs, auxiliary input, Bluetooth audio input, and IR remote.
    a. Denon DN-300Z
    b. Equal
        1) Quantity: 1

F. Media Dock
1. Provide rack-mounted compartment with cabling grommets designed for use with portable media players. Provide with Bluetooth Interface (1) pair stereo phone (RCA) connectors with 1/8-inch stereo phone plug to RCA cable for connection to other portable media players. Provide interfaces for connection to separate stereo audio inputs. Provide with integral power/USB outlets mounted on back panel of shelf, per Drawings.
    a. Middle Atlantic SH-DMP-S w/ AV Plate, Networked
    b. Raxxess Equal
    c. Lowell Equal
        1) Quantity: 1

G. Ceiling Loudspeakers (S2)
1. Provide 70.7-volt 6.5-inch coaxial loudspeaker/transformer assembly with low-profile enclosure and grille for flush mounting in ceiling.
    a. QSC AD-6CT-LP
    b. JBL Equal
    c. Tannoy Equal
        1) Quantity: per Drawings

H. High-Ceiling Loudspeaker (SH)
1. Provide 70.7-volt 8-inch 2-way coaxial loudspeaker/transformer assembly with enclosure and grille for flush mounting in ceiling. Provide loudspeaker with 75-degree conical coverage pattern. Provide with safety cable.
    a. Electrovoice C8.2HC
    b. JBL Equal
    c. Equal
        1) Quantity: per Drawings

I. Power Amplifier
1. Provide two-channel power amplifier with balanced bridging inputs, continuously variable-speed fan(s) or convection cooled. Provide amplifier which provides at least 300 watts output (nominal) per channel into 70 volts.
    a. Crown DCi 2|300
    b. Equal
        1) Quantity: 1

2.34 CAFETERIA EQUIPMENT RACK AND ACCESSORIES

A. Wall Box (WBM)
   1. Provide wall box with gang opening as shown on Drawings. Provide with locking cover with flip-up cable exit door. Provide flush-mounting flat paintable locking white door. Provide with back box.
   2. Provide with blanks a required to fill in empty openings.
      a. FSR WB-X3-GNG w/ WB-X3-CVR-WHT
      b. Equal
         1) Quantity: 1

B. Equipment Rack
   1. Provide floor-mounted equipment rack with pivoting center section, floor base, and vented, lockable front door. Fill in unused rack space with blank solid panels, per industry best practices for air flow. Provide rack, accessories, and filler panels in smooth (not wrinkle) matte black finish. Provide with thermostatically controlled fan kit.
      a. Middle Atlantic SR-40-32 w/ DWR-FK32, FC-2-215-1CA
      b. Equal
         1) Quantity: 1

C. System Power Control
   1. Provide an IP-controlled rack-mountable power switching system. Provide a means to cycle the system power amplifiers on sequentially at intervals of approximately one second whenever the system is initialized from the touch screen control panels.
      a. iBoot-PDU8-2N20
      b. Equal
         1) Quantity: 1

D. High Density Vertical Power Strip
   1. Furnish equipment racks with permanently-mounted 3-conductor AC power receptacles with sufficient outlets to meet system needs plus at least 4 spares per rack. Provide raceway configured with 20A outlets. Connect to remotely controlled outlets per the Drawings and as required to meet all specified functionality.
      a. Middle Atlantic PD-2420SC-NS
      b. Juice Goose equivalent
         1) Quantity: 2

2.35 CAFETERIA VIDEO EQUIPMENT

A. Input Panel
   1. Provide one-gang digital transport input panel with HDMI connector. Provide unit with support for 4k60 4:4:4 and HDR video signals. Provide device which transports all video signals digitally to the A/V switcher over a single category cable. Provide with faceplate cover to match.
   2. White or black, per Architect.
      a. Crestron DM-TX-4KZ-100-C-1G-B-T
      b. Extron Equal
      c. AMX Equal
         1) Quantity: 1

B. Audiovisual Matrix Switcher and Controller
   1. Provide audiovisual matrix switcher and integrated system control processor with the following properties:

a. Local HDMI inputs: 4
b. Local RGB inputs: 4
c. Remote category cable digital video inputs: 1
d. Local HDMI outputs: 1
e. Remote category cable digital video outputs: 1
f. Bidirectional RS-232 ports: 1
g. Microphone Input
h. Logic inputs: 2
i. IR Outputs: 1
j. Program audio output
k. Ethernet support
l. HDCP key management
m. EDID management
n. Fast HDMI switching
o. CEC signal management
p. HDBT-compatible projector output
    1) Crestron DMPS3-4K-150-C
    2) Extron DTP Series Equal
    3) AMX Equal
        a) Quantity: 1

C. Blu-ray Player
1. Provide Blu-ray disc player with RS-232 and Ethernet control, DVD support and rack mounting kit.
    a. Denon DN-500BD
    b. Equal
        1) Quantity: 1

D. Network Video Presenter
1. Provide presentation gateway designed to receiver wireless audio and video signals and transmit over HDMI connector. Provide with rack-mount shelf. Coordinate networking with Owner's IT department.
    a. Crestron AM-3200
    b. Extron ShareLink 250
    c. Mersive Solstice Pod
        1) Quantity: 1

E. Video Projector
1. Provide solid-state video projector with 10,000 ANSI lumen output (minimum), 2,000,000:1 contrast ratio (minimum), HDBaseT input, and a native aspect ratio of 16:10 and minimum resolution of 1920x1200. Provide projector with zoom lens. Verify final throw distance to projection screen, screen size and geometry before ordering lens.
    a. Sony VPL-PHZ101LW w/ zoom lens
    b. NEC PA1004UL-W w/ zoom lens
    c. Epson Pro L1505U w/ zoom lens
    d. Panasonic Equal
        1) Quantity: 1

F. Video Projector Security Enclosure
1. Provide steel security cage sized to fit provide projector. Provide with integrated projector mount and all accessories required to hang from structure above. Provide in black or white, per Architect.
    a. Display Devices SC-PCM
    b. Equal
        1) Quantity: 1

2.36 CAFETERIA CONTROL EQUIPMENT

A. Rack Mount Touch Panel
1. Provide 7" diagonal touch panel with 800x480 resolution. Provide touch panel that can be controlled and powered by single Category cable. Provide with rack mount.
a. Crestron TSW-770-B-S
b. Extron TLP Pro 720M
c. AMX Equal
1) Quantity: 1

B. Wireless Touch Panel
1. Provide capacitive 2-point 8.7" diagonal wireless touch panel with 1008x588 resolution. Provide with charging base. Mount on rack shelf in equipment rack. Provide complete with re-chargeable battery and all required accessories.
a. Crestron TST-902
b. Extron Equal
c. AMX Equal
1) Quantity: 1

C. Wireless Touch Panel Gateway
1. Provide bi-directional wireless gateway for Wireless Touch Panel. Mount above equipment rack. Provide with all required power supplies, injectors, cables and accessories.
a. Crestron CEN-GWEXER
b. Extron Equal
c. AMX Equal
1) Quantity: 1

2.37 CAFETERIA ASSISTIVE LISTENING EQUIPMENT

A. Assistive Listening Transmitter
1. Listen Technologies LT800 with LA-326 rack mounting kit
2. Williams PPA T35 with RPK 006 rack mounting kit
3. Equal
a. Quantity: 1

B. Assistive Listening Antenna
1. Listen Technologies LA-124
2. Williams Equal
3. Equal
a. Quantity: 1

2.38 ATHLETIC FIELD SYSTEM

A. Main Equipment Rack
1. Provide floor-mounted equipment rack with pivoting center section, floor base, and vented, lockable front door. Fill in unused rack space with blank solid panels, per industry best practices for air flow. Provide rack, accessories, and filler panels in smooth (not wrinkle) matte black finish. Provide with thermostatically controlled fan kit.
a. Middle Atlantic SR-40-32 w/ DWR-FK32, FC-2-215-1CA
b. Equal
1) Quantity: 1

B. Rack Power Wiring
1. Furnish equipment racks with permanently-mounted 3-conductor AC power receptacles with sufficient outlets to meet system needs plus at least 4 spares per rack. Provide raceway configured with separately circuited receptacle groups as required to distribute load across multiple circuits. Provide whip for connection to power junction box as indicated on the power plan drawings.
    a. Juice Goose CQ-PD1-4, CQ2200, CQ2000 (special order IG version)
    b. Middle Atlantic MPR Series w/ RLM-20IG modules
        1) Quantity: As required

C. System Power Control
1. Provide a relay-controlled power switching system with a master power switch and power-on indicator for the system. Connect the master power switch to control each receptacle in the rack except for one of the spare receptacles. Label unswitched receptacles "UNSWITCHED". Connect power for rack illumination to bypass the system master power switch. Provide a means to cycle the system power amplifiers on sequentially at intervals of approximately one second whenever the power switch is activated.
    a. Middle Atlantic USC-6R
    b. Atlas Sound SACR-191
    c. Juice Goose CQ1520
        1) Quantity: 1

D. Rack Work Light
1. Provide magnetically mounted gooseneck locally switched LED utility lighting. Connect to unswitched receptacle. Mount in back of equipment racks.
    a. Middle Atlantic LT-GN-WL
    b. Equal
        1) Quantity: 1

E. Wireless Microphone System (Main Rack)
1. Provide all antennas, transmitters, and receivers by a single manufacturer.
2. Provide digital wireless microphone system with AES 256-bit encryption, Dante audio networking, allow up to 16 active transmitters on one 6 Mhz TV channel, switching diversity.
3. Provide all required power supplies and accessories to achieve intent of Drawings.
4. Provide complete with rack-mounting kits.
    a. Dual-Channel Receiver
        1) Shure ULXD4D
        2) Equal
            a) Quantity: 1
    b. Handheld Transmitter
        1) Shure ULXD2/SM58
        2) Equal
            a) Quantity: 2
    c. Beltpack Transmitter
        1) Shure ULXD1
        2) Equal
            a) Quantity: 1
    d. In-Line Mute Switch
        1) Shure WA661
        2) Equal
            a) Quantity: 1
    e. Headworn Microphone
        1) Provide hypercardioid headworn condenser microphone.

a) Shure WCM16
b) Equal
c) Quantity: 1

f. Rechargeable Battery
1) Shure SB900
2) Equal
a) Quantity: 4

g. Charging Station
1) Shure SBC200-US
2) Equal
a) Quantity: 2

h. Antenna
1) Provide weatherproof antenna suitable for use with wireless microphone receiver. Provide with power inserter.
2) Mount to top of Press Box.
a) Winegard FlatWave Air
b) Equal
c) Quantity: 2

F. Desktop Microphone
1. Provide console assembly with gooseneck microphone and weighted base. Provide base with one momentary for push-to-talk. Provide with cable for connection to wall plate in Press Box.
a. Clock Audio DMB1 w/D43 Gooseneck
b. Equal
1) Quantity: 1

G. Digital Signal Processor
1. Provide digital signal processing system with inputs and outputs as shown on drawings, and the following functions. Provide all required devices, accessories, switches and cables to achieve a complete working system.
a. Feedback suppression
b. Nine bands of parametric equalization per signal input group
c. Crossover
d. Compressor
e. Digital delay
f. Signal limiting
g. Digital audio signal routing
h. Signal flow as shown on sound system functional drawing(s)
i. Volume control
j. Dante Ethernet based digital audio networking
1) BSS London BLU
2) Biamp Tesira
3) Symetrix EDGE
4) QSC Q-Sys
a) Quantity: 1 complete system, as required

H. Ethernet Switch
1. Provide SNMP capable, POE+ enabled, gigabit Ethernet switches as required to support a Dante audio network with functionality equivalent to audio network shown on drawings and control system network. Provide Ethernet products compliant with IEEE 802.3.
a. Cisco
b. Pakedge
c. HP

d. Equal
1) Quantity: 1

I. DSP Control Panel
1. Provide desktop control surface compatible with Digital Signal Processor. Provide unit with POE+ power, twelve motorized faders, Ethernet-based control communications and a minimum of twelve programmable back-lit push buttons.
2. Provide with 15-foot Ethernet cable to connect to panel in Press Box.
a. Mystery Electronics FC12X
b. Equal
1) Quantity: 1

J. Portable Audio Mixing Console
1. Provide 12-channel compact audio mixer with four microphone level inputs, 12 line-level inputs, control room outputs, balanced main output, sealed rotatory controls, and steel chassis.
2. Provide with 15-foot cable to connect to wall panel in Press Box.
3. Provide with dustcover.
a. Mackie 1202VLZ4
b. Equal
1) Quantity: 1

K. Power Amplifier, 8 Channel
1. Provide eight-channel, power amplifier with balanced bridging inputs, continuously variable-speed fan(s). Provide amplifiers which are 2-rack space units high. Provide amplifiers which provide at least 600 watts output (nominal) per channel into 4 ohms and 600 watts output (nominal) per channel into 8 ohms.
a. Crown DCi 8|600
b. Equal
1) Quantity: 1

L. Power Amplifier, Field Loudspeakers Low Frequency
1. Provide two-channel, power amplifier with balanced bridging inputs, continuously variable-speed fan(s). Provide amplifiers which are 2-rack space units high. Provide amplifiers which provide at least 1200 watts output (nominal) per channel into 4 ohms and 1200 watts output (nominal) per channel into 8 ohms.
a. Crown DCi 2|1250
b. Equal
1) Quantity: 1

M. Field Loudspeaker
1. Provide 3-way full range weather-resistant loudspeaker with dual 12-inch low-frequency drivers, 2-inch mid-range driver and 1.4-inch compression driver, and 90x40 degree coverage pattern. Provide with U-bracket to attach to pole mount.
2. Color per Architect.
a. Community R2-94MAX
b. Equal
1) Quantity: 2

N. Bleacher Loudspeaker
1. Provide 2-way full range weather-resistant loudspeaker with 8-inch low-frequency driver and .75-inch high-frequency driver, and 90x40 degree coverage pattern. Provide with U-bracket to attach to pole mount.
2. Color per Archtiect
a. Community R.25-94z

b. Equal
1) Quantity: 3

O. Bleacher Loudspeaker Mounting Hardware
1. Provide wind-rated pole mount designed to mount to outdoor athletic light pole. Provide with all required accessories and hardware to suspend loudspeaker from u-bracket.
a. Polar Focus PM2-10
1) Quantity: 2

P. Loudspeaker Suspension Equipment
1. Provide contractor fabricated and designed loudspeaker rigging for loudspeaker clusters and suspended loudspeakers. Suspend loudspeaker components from brackets and any necessary suspension frames to minimize total number of ceiling hanging points. Provide with a sufficient number of suspension points for field adjustment of loudspeaker aiming. Provide with color as designated by the Architect. During fabrication and installation verify that adequate clearance from all other hanging components and adequate clearance from structural steel is provided. Provide any additional rigging hardware necessary for the safe and proper installation of these loudspeakers.
2. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the Work include, but are not limited to, the following:
a. Ape Rigging
b. Polar Focus
c. ATM-Flyware
d. Approved Contractor-Fabricated Assembly (*Show evidence of successful completion of previous projects)
3. Submit all drawings of the complete final loudspeaker rigging assemblies to a certified structural engineer and obtain approval and stamped copies of the drawings. Drawings should detail all connections from attachment to building structure to loudspeaker.

2.39 ATHLETIC FIELD ASSISTIVE LISTENING EQUIPMENT

A. Provide wireless assistive listening system consisting of an FM transmitter, an antenna mounted as indicated on drawings, and portable battery-operated receivers with earphones and inductive couplers (the latter for use with hearing aids with "T" switches). Provide frequencies separate and free from interference with other FM systems. Provide all assistive listening system components from the same manufacturer.

B. Transmitter
1. Listen Technologies LT800 with LA-326 rack mounting kit
2. Williams PPA T35 with RPK 006 rack mounting kit
a. Quantity: 1

C. Transmitter Antenna

1. Provide coaxial di-pole antenna suitable for use with FM transmitter.
a. Listen Technologies LA-116
b. Williams ANT 005 with extension cable

2. Quantity: 1

2.40 SHARED ASSISTIVE LISTENING RECEIVERS

A. Receiver
1. Provide belt-pack receiver capable of receiving signals in each room with an FM-based ALS system. Provide with rechargeable batteries.
a. Listen Technologies LR-300 w/ LA-162, batteries

b. Williams PPA R35-8N with EAR 014 earphones

c. Quantity: 60

B. Replacement Cushion
1. Listen Technologies LA-163
2. Williams EAR 015-10
a. Quantity: 200 replacement pads

C. Over-Ear Earphones
1. Listen Technologies LA-164
2. Williams EAR 008
a. Quantity: 15

D. Neckloop Induction Coil
1. Listen Technologies LA-166
2. Williams NKL 001
a. Quantity: 15

E. Portable Charging Case
1. Provide portable charging cases with total capacity equal to or greater than quantity of receivers specified above.
a. Listen Technologies LA-311
b. Williams CHG 3512 PRO
1) Quantity: as required

PART 3 - EXECUTION

3.1 INSTALLATION

A. Supply and install any racks, wire, conduits, pull boxes, junction boxes and raceways required to provide a complete system. Unless specifically instructed to the contrary, install all system wiring in steel conduit. Do not exceed 30% fill in conduits.

B. Use separate steel conduits for microphone-level circuits (below -20 dBm), line-level circuits (up to +30 dBm), loudspeaker circuits (above +30 dBm), control circuits, and power circuits. Use audio conduit which is spaced well away from power conduit. Insulate all conduit from the equipment rack(s); ground conduit only to power system ground. Do not splice lines in conduit. Connect each input receptacle by an individual, insulated line to the system equipment rack.

C. Secure equipment firmly in place, including control panels, loudspeakers, conduit, amplifiers, racks, and cables. Make fasteners and supports adequate to support their loads with a safety factor of at least three.

D. Take precautions to prevent electromagnetic and electrostatic hum. Install the equipment to provide safe operation.

E. Use terminal strips or blocks in all audio lines entering or leaving the system equipment rack(s). Make all joints and connections with rosin-core solder or with mechanical connectors appropriate for the service. Execute all wiring in strict adherence to standard broadcast practices.

F. Assemble and install equipment racks to permit access to connections and adjustments on the rear of rack-mounted components and to permit removal of components for servicing. For any components which, for purposes of adjustment or calibration, must be removed from an equipment rack while in use, provide adequate service loops on all connecting cables.

G. Provide safety cables prevent individual loudspeaker components from falling in case of failure or loosening of the primary component support. Paint all exposed components as directed by the Architect.

H. Locate microphone and line receptacles as directed by the Architect. Except for receptacles mounted in equipment cabinets or in floors or designated as surface-mounted, flush-mount other receptacles on cover plates in gang boxes recessed in vertical surfaces. Provide plate finish as approved by the Architect.

I. Install work neatly, with boxes, equipment, etc., plumb and square. Keep the job adequately staffed at all times. Designate an employee as field supervisor to be present on the job site and in responsible charge during all phases of installation and check-out. Maintain same supervisor through completion of the work unless the designated supervisor ceases to be an employee or unless by mutual agreement with the Owner or Architect. Install the system in cooperation with other trades in order to achieve coordinated progress and satisfactory final results. Watch for conflicts with work of other trades on the job. Execute, without claim for extra payment, moderate moves or changes as are necessary to accommodate other equipment or preserve symmetry and pleasing appearance.

J. Clearly, consistently, logically and permanently mark switches, connectors, jacks, relays, receptacles, cables, and cable terminations. Engrave and paint-fill all panel and receptacle markings, directly on the material on which controls or receptacles are mounted. Fill engraving with black or white paint, whichever contrasts best with panel finish, or as directed by the Architect. Use no hand-lettering, embossed tape (e.g. "Dymo" labels), or any adhesive- or otherwise mechanically-attached labels for any labels visible to operators or public during normal system operation. Use adhesive- or screw-attached engraved or laminated labels (e.g., "Kroy" or "Brother") on manufactured assemblies, such as amplifiers, which otherwise would require disassembly for direct engraving. Use printed adhesive cable markers to mark cables, or other labels intended for the purpose. Use "Kroy" or "Brother" or similar machine-produced laminated labels, or "letter quality" or "near letter quality" mechanically-produced lettering for patch panel labels. Insert patch panel labels into clear plastic-covered label holders.

K. Label each receptacle with its type and a unique number; for example, "MIC 18", "FP3" "A/V Input Panel 5". Label each jack with the name of the device to which it is connected, plus "IN" for input or "OUT" for output. In addition, label horizontal rows of jacks with letters "A", "B", etc., and vertical columns with numbers "1", "2", etc.

L. Paint or provide approved factory finishes for all system components exposed to public view as directed by Architect. Paint or otherwise remove all visible manufacturers' trademarks exposed to public view as directed by Architect.

M. If any item of equipment includes exposed controls which are not used in system operation, and if those controls cannot be locked, capped, or concealed behind a security cover, mount said item of equipment recessed behind a blank rack panel.

N. Save all unused products accessories and turn over to Owner at checkout.

3.2 PROTECTION AND REPAIR OF EXISTING FINISHES AND STRUCTURES

A. Cut and patch all holes required for this installation.

B. Make good all materials and finishes cut into or damaged during installation.

C. On completion, remove all rubbish and unused materials from the premises, clean the premises where dirtied, and clean all equipment, removing all dirt, dust, stains, and fingerprints.

3.3 ELECTRONIC TEST EQUIPMENT

A. Provide the following test equipment for use during tests and adjustments and during acceptance testing and final adjustment of the system.
1. Continuously Variable Sine Wave Generator - 20 Hz to 20,000 Hz range within +1 dB with less than 0.5% THD at 1 volt output into 600 ohms.
2. AC Voltmeter with frequency response within +1 dB from 20 to 20,000 Hz, 0.0001 volts to 100 volts, minimum input impedance 0.1 meg ohm.
3. Multimeter (VOM) (may be included with AC Voltmeter)
4. Oscilloscope with at least 5 MHz bandwidth and external horizontal input. Vertical sensitivity to 10 mV/division or less.
5. Impedance Measuring Device, capable of measuring at 1,000 Hz and within each loudspeaker's passband (at center of passband or at least one octave removed from crossover frequency), minimum range 0 to 1,000 ohms.
6. Light Meter: The meter shall be capable of measuring illuminance (foot-candles) and luminance (foot lamberts).
7. NTSC Color Video Test Signal Generator: The test signal generator shall be capable of generating SMPTE color bars, multiburst, modulated ramp or stair step, and window signals.
8. Video Sweep Generator: The generator shall be capable of producing sine wave frequency sweep from 30 Hz to 100 MHz, locked to horizontal sync.
9. Wideband Video Distribution Amplifier: Provide a one input three output (minimum) distribution amplifier with frequency response at least -3dB at 100 MHz.
10. RGB Test Signal Generator: The generator shall be capable of generating the SMPTE RP-133 test pattern and window pattern on black background over entire range of horizontal and vertical scan frequencies of the video projector(s) specified.
11. Waveform Monitor and Vectorscope: The monitor(s) shall provide facilities for complete line select and simultaneous channel A and B display. The unit shall be able to make differential phase and gain measurements. Inputs shall be able to be displayed in one or two line sweeps. The vectorscope shall be able to measure SC/H phasing and color framing.
12. Real Time Audio Analyzer: Shall provide a pink noise generator, a calibrated microphone and graphic representation of the audio spectrum in 1/3-octave increments.
13. Connectors, Adapters, Cables, etc. to permit flexible interconnection of test equipment and convenient, reliable connection to receptacles, patch panels and amplifier terminal strips.
14. Network Cable Analyzer: Certification-grade cable analyzer suitable for testing up to TIA Category 6A cable and testing cable length, bandwidth, and attenuation.
15. Fiber Optic Cable Analyzer: Certification-grade optical power and fiber optic test kit suitable for testing fiber length, bandwidth, and attenuation.
16. Laptop personal computer with software as provided for any computer-controlled equipment.
17. Table to support test equipment at system equipment rack, minimum 30" square. (Required only during acceptance testing.)

3.4 SHOP AND FACTORY TESTING

A. The Audiovisual Contractor shall perform preliminary tests at their shop or factory before the system is shipped to the Owner's site. The Owner's Authorized Representative, Owner's Project Manager, Consultant or other designated representative may be present for these tests. These tests shall include Contractor-provided equipment and any Owner provided equipment (equipment that the Owner shipped to the assembly site). The tests shall include equipment provided by other Vendors, if applicable, plus all installation service and materials.

3.5 INITIAL POST-COMPLETION TESTS AND ADJUSTMENTS

A. Perform these tests and adjustments. Furnish equipment necessary to perform these tests, and perform work required to modify the performance of the system in accordance with this specification.
   1. Loudspeaker Line Impedance
      a. Measure the resistance and impedance of each loudspeaker line leaving the system equipment rack, with the line disconnected from its normal driving source. Measure impedance within each loudspeaker's passband (at center of passband or at least one octave removed from crossover frequency). Verify that values are within +10% of the value calculated for that circuit based upon the parallel impedances/resistances of the loudspeakers connected plus the resistance of the loudspeaker line. Correct any discrepancies.
   2. Loudspeaker Phasing
      a. Perform phasing checks of loudspeaker lines by means of a DC source at one end of each line and a voltmeter at the other end. Phase all loudspeaker lines identically with respect to color coding.
   3. Hum and Noise Level
      a. Measure the hum and noise levels of the overall system. Adjust gain controls for optimum signal-to-noise ratio. The adjustment shall also be such that full power amplifier output would be achieved with +8 dBm input. Terminate inputs with shielded resistors of 600 ohms for these measurements. Disconnect the loudspeaker lines and terminate the power amplifier outputs with power resistors for these measurements. Use load resistors matching the rated load impedance and output power of the amplifier.
   4. Power Output and Signal Level Adjustments
      a. Measure the electrical distortion of the overall system. Adjust gain controls as for the tests specified in the preceding paragraph. Set variable equalizers for flat response. Apply a 1,000 Hz sine-wave signal to the input tested, at a level required to produce full amplifier output. Use a distortion analyzer to measure the output level and total harmonic distortion of the amplification equipment. (In the absence of a distortion analyzer, a VTVM or transistor voltmeter may be used to measure the output level, and lack of clipping or apparent deformation of a sine-wave input signal at the power amplifier output, as seen on an oscilloscope as specified, may serve as evidence that distortion of amplification and control equipment is within acceptable limits, subject to review by the Architect.) Make all measurements with loads actually incurred in system operation. (Power amplifier loads shall be resistors equal to the nominal impedance of the output terminals used in the system.)
   5. Freedom from Parasitic Oscillation and Radio-Frequency Pick-up
      a. Check to insure that the system is free from spurious oscillation and radio-frequency pick-up, both in the absence of any audio input signal and also when the system is driven to full output at 100 Hz. Employ an oscilloscope as specified.
   6. Freedom from Buzzes, Rattles, and Objectionable Distortion

a. Apply a slow sine-wave sweep from 50 to 5,000 Hz at a level of 6 dB below rated power amplifier output voltage. Listen carefully for buzzes, rattles, and objectionable distortion. Correct any causes of these defects, unless the cause is clearly outside the sound amplification system equipment and installation, in which case bring the cause to the attention of the Architect.

7. Gain Control Settings
   a. Establish tentative normal settings for all gain controls. Adjust all gain controls for optimum signal-to-noise ratio and signal balance.
8. Freedom from Switching Transient Noise
   a. Eliminate audible clicks or pops produced by the operation of any controls.
9. Listening Test
   a. Listen to normal program material to be sure that there are no remaining defects.
10. Test of Signal Routing
    a. Verify that signal flow is as intended.
11. Digital Signal Transport System
    a. Verify number of HDCP keys supported by each source device.
    b. Video timing and support audio formats (if applicable) for each display device.
    c. Video timing and supported audio formats presented in the EDID for each source. Indicate preferred video timing.
    d. Length of installed twisted pair cables used for signal distribution and control.
12. Video Projectors
    a. Employ an RGB test generator to produce signals with horizontal scan frequencies of 15.75 kHz, 35 kHz, 64 kHz and other frequencies as directed. Align projectors to meet manufacturer's published specifications for all such input signals. Verify that the image size specified can be achieved, and that keystone distortion is absent. Verify the absence of any other geometry errors, including bow, skew, trapezoid, linearity, and vignetting.
    b. Verify proper registration and focus of each tube to within the performance limits of the projector. Adjust horizontal blanking to preclude the loss of image on the sides. Verify that any remaining registration errors do not prevent the projector from performing in the intended application.
13. Subjective Image Quality
    a. Observe the image quality on various displays throughout the system, employing various sources such as workstations and videotape, and check for errors of linearity, chroma-luminance delay, signal to noise performance, blanking and gain shifts, RF interference, crosstalk, and other imperfections. Test for these errors under various operating conditions, including selecting random sources into selected projectors.
14. Control System
    a. Verify that all devices being controlled by the master control system respond to corresponding graphic elements on touch screens. Check all screens for full functionality. Test touch panels at all connection locations.
15. Category Cabling
    a. Verify that all jacks have been terminated properly and conform to ANSI/TIA/EIA-568-C.
    b. Provide list of cable runs each with associated bandwidth and length information, as well as pass/fail for ANSI/TIA/EIA-568-C compliance.
16. Fiber Optic Cabling
    a. Verify that all jacks have been terminated properly and conform to ANSI/TIA/EIA-568-C and related ANSI/TIA/EIA fiber optic standards.
    b. Provide list of fiber runs each with associated bandwidth and length information, as well as pass/fail for ANSI/TIA/EIA-568-C compliance.
17. 75 Ohm Coax Video Cabling
    a. Verify that all jacks have been terminated properly and meet SMPTE SDI, HD-SDI, and 3G-SDI standards 259M, 274M, 292M, 296M, 344M, 327M, and 424M.

b. Provide list of cable runs each with associated bandwidth and length information, as well as pass/fail for SMPTE SDI, HD-SDI, and 3G-SDI standards 259M, 274M, 292M, 296M, 344M, 327M, and 424M.

B. Report
1. Upon completion of above tests and adjustments submit two copies of a written report presenting test results, including numerical values and corrective actions taken, for review by the Architect and Architect prior to demonstration and acceptance testing. With this report, submit written certification that the installation conforms to the requirements stated herein, is complete in all respects, and is ready for inspection and testing by the Architect.

3.6 DEMONSTRATION AND ACCEPTANCE TESTING OF COMPLETED INSTALLATION:

A. Upon approval of the above test report by the Architect and at a mutually agreeable time, demonstrate operation of each major component and of the complete installation. After demonstration, assist as required in acceptance tests.

B. Listening Tests
1. Tests will include subjective evaluation by observers listening at various positions under various operating conditions of the system, intended to test its operation in conformance with its functional requirements.

C. Equipment Tests
1. Perform any measurements of frequency response, distortion, noise or other characteristics and any operational tests deemed necessary by the Architect to determine conformity with these requirements.
2. If the need for adjustment or modification becomes evident during demonstration and testing, continue working until the installation operates properly.

D. Final Adjustments
1. Make adjustments, including, but not limited to control systems and loudspeaker aiming, as directed by the Architect. Make a record of these settings. Provide covers, caps, or shaft-locks for controls not used in system operation.

END OF SECTION

Section 27 41 20

IN-CEILING INSTRUCTIONAL AUDIO SYSTEM

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. It is the intent of these specifications that the Contractor, Manufacturer and/or its Authorized System Integrator expeditiously furnishes and installs a system complete in every respect and ready to operate. All miscellaneous items and accessories required for such installation, whether or not each such item or accessory as shown on the plans or mentioned in these specifications, shall be furnished and installed.

B. The in-ceiling instructional audio system shall be installed as shown on the drawings and as specified herein. The work covered by this section of the specifications includes the furnishing of all labor, equipment, materials and performance of all operations associated with the in-ceiling classroom audio system for a fully functional system.

C. The school district has standardized on the Lightspeed wireless classroom in-ceiling instructional audio system. This Contractor shall provide Lightspeed Topcat In-Ceiling Instructional Audio System at each location where an in-ceiling classroom audio system speaker is shown on the drawings and as specified herein.

1.4 CODES AND STANDARDS

A. Complete installation shall meet or exceed the latest edition of following standards:

1. TIA-568: Commercial building telecommunications wiring standard and all current addenda.
2. TIA-569: Commercial building standard for telecommunications pathways and spaces.
3. TIA-606: Administration standard for telecommunications infrastructure of commercial buildings.
4. TIA-607: Commercial building grounding and bonding requirements for telecommunications.

5. ANSI, ASTM, UL, NEMA, IEEE and FCC standards as applicable.
6. BICSI Telecommunications Distribution Methods Manual, current edition.

1.5 PROGRAMMING

A. Coordinate and obtain a written approval of system functionality from the Owner prior to programming.

B. Perform a walk-through with the Owner and demonstrate the system functionality.

C. Make any adjustments to system functionality after initial programming if necessary to achieve the desired functionality requested by the Owner. Coordinate all required reprogramming with the Owner as required as part of this contract.

D. Obtain a written final letter of acceptance from the Owner upon completion of system functionality programming and demonstration.

1.6 SUBMITTALS

A. Comply with requirements specified in Division 01 and the following:

1. The vendor shall submit certification letter from the manufacturer of submitted equipment certifying that the installer is an authorized and certified installer of the submitted equipment.
2. The vendor shall make all connections at all field devices and at the head-end; and shall make all necessary field adjustments for a fully functional system.

B. Shop Drawings

1. Prior to assembling or installing the system, the Contractor shall provide complete shop drawings which include the following:
   a. List the name of the manufacturer’s local representative and his/her phone number.
   b. Table of contents.
   c. Manufacturer’s parts lists
   d. Product serial numbers
   e. Catalog cut sheets
   f. Installation instructions
   g. Typical wiring diagrams
   h. Drawings showing equipment locations
   i. Manufacturer’s warranty documents

2. All drawings shall be fully dimensioned.
3. Operating License: Submit evidence of application for FCC Radio Station Authorization prior to installing equipment when required for operation of the equipment.

C. As-Built Drawings

1. At the conclusion of the project, the Vendor shall provide “as built” drawings. The “as built” drawings shall be a continuation of the Contractors shop drawings as modified, augmented, and reviewed during the installation, check out and acceptance phases of the project. All drawings shall be fully dimensioned and prepared in DWG format using the latest version of AutoCAD.

2. The as-built drawings shall incorporate all updated system riser diagrams prepared in DWG format using the latest version of AutoCAD.

D. Manuals

1. At the conclusion of the project, the Vendor shall provide copies of the manuals as described herein. Each manual's contents shall be identified on the cover. The manual shall include names, addresses, and telephone numbers of each system integrator installing equipment and systems and the nearest service representatives for each item of equipment for each system. The manuals shall have a table of contents and labeled sections. The manuals shall include all modifications made during installation, checkout, and acceptance. The manuals shall contain the following:
   a. Hardware Manual
      1) The hardware manual shall describe all equipment furnished including:
      2) General description and specifications
      3) Installation and check out procedures
      4) Equipment layout and electrical schematics to the component level
      5) System layout drawings and schematics
      6) Alignment and calibration procedures
      7) Manufacturers repair parts list indicating sources of supply
   b. Software Manual
      1) The software manual shall describe the functions of all software and shall include all other information necessary to enable proper loading, testing, and operation. The manual shall include:
      2) Definition of terms and functions
         a) Use of system and applications software
         b) Initialization, start up, and shut down
         c) Alarm reports
         d) Reports generation
         e) Data base format and data entry requirements
         f) Directory of all disk files

2. Operators Manual
   a. The operator's manual shall fully explain all procedures and instructions for the operation of the system including:
      1) Computers and peripherals
      2) System start up and shut down procedures
      3) Use of system, command, and applications software
      4) Recovery and restart procedures
      5) Use of report generator and generation of reports
      6) Data entry
      7) Operator commands
      8) Alarm messages and reprinting formats
      9) System access requirements

3. Maintenance Manual
   a. The maintenance manual shall include descriptions of maintenance for all equipment including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective components.

1.7 MAINTENANCE SERVICE

A. The Contractor shall provide a one-year guarantee of the installed system against defects in material and workmanship. All labor and materials shall be provided at no expense to the Owner. Guarantee period shall begin on the date of acceptance by the Owner or engineer.

B. A maintenance contract offering continued factory authorized service of this system shall be made available if requested by the Owner.

1.8 QUALITY ASSURANCE

A. The Contractor shall currently maintain a locally run business for a minimum of five years and shall be an authorized distributor of the supplied equipment with full warranty privileges.

B. The Contractor shall maintain at his facility the necessary spare parts in the proper proportion as recommended by the equipment manufacturer to maintain and service the equipment being supplied. This facility shall be available for inspection by the engineer.

C. The supplying Contractor shall have attended the manufacturer's installation and service school.

D. The Contractor shall furnish manufacturer's manuals of the completed system including individual specification sheets, schematics, inter-panel and intra-panel wiring diagrams. In addition, all information necessary for the proper operation of the system must be included. Any bidder using other than the specified equipment must provide this information prior to bidding.

E. As built drawings that include any changes to wiring, wiring designations, junction box labeling and any other pertinent information shall be supplied upon completion of project.

F. Vendors providing equipment installation services shall use adequate numbers of skilled workmen who are certified by the component manufacturer, thoroughly trained and experienced with the necessary technology and systems, and completely familiar with the specified requirements and methods needed for proper performance of work. The system head-end installation, start-up and commissioning shall be by the manufacturer certified vendor.

G. Each vendor is required to provide a letter from the manufacturer indicating that they hold a current certification for the specified system.

H. Use adequate numbers of skilled workers thoroughly trained and experienced on the necessary crafts and completely familiar with the specified requirements and methods needed for the proper performance of the work of this Section. Contractor is required to provide references of three similar installations completed in the last 12 months.

I. Contractor must provide a project manager who has demonstrated the ability to supervise a project of this magnitude. The Project Manager must be available to attend meetings as required. Acceptance will not be unreasonably withheld.

1.9 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers

1. Lightspeed.

2.2 BASIS OF DESIGN

A. The system specified is based upon the Lightspeed Topcat In-Ceiling Instructional Audio System and represents the performance standard upon which any equivalent solution shall be based.

B. Provide Lightspeed Lightspeed Topcat In-Ceiling Instructional Audio System at each location where an in-ceiling instructional audio system speaker is shown on the drawings.

2.3 SYSTEM DESCRIPTION

A. The system must have specifications and features that are equivalent to the Lightspeed Topcat In-Ceiling Instructional Audio System including the following:

1. All-in-one, in-ceiling audio system with integrated amplifier, speakers and wireless audio receiver/transmitter.
2. Two-way hybrid speaker system with exciter technology sound panel and low frequency cone driver.
3. Cross over technology to deliver high speech intelligibility and full range sound with even distribution throughout the classroom.
4. Up to 2 microphones for whole room instruction, team-teaching or student sharing.
5. Pendant-style Flexmike™ classroom microphone with audio input utilizing Access Technology (1.9 GHz) for transmission. IR not acceptable.
6. PageFirst emergency page priority.
7. Relay closure input to mute all classroom audio when signal is detected.
8. Contact Closure output to trigger alert or other action from teacher microphone.
9. In-Ceiling mounted.
10. Suitable for use in air-handling spaces (plenum-rated).
11. System must have easily accessible audio output to connect with a computer or other recording device for lesson capture.
12. Activate Charging Station with Access Technology, Bluetooth, and Wireless Media Connectivity for integration with mobile devices and laptops:
    a. Includes 2 channels of 2-way Bluetooth Audio.
    b. 4 audio input connections, 2 audio outputs with volume controls.
    c. Cradle charging for 2 pendant microphones, eight (8) 2-way audio Pods.
    d. USB ports to charge up to four (4) additional 2-way audio Pods.
    e. Bluetooth connection with Activate mobile app for control, streaming and audio/video recording of classroom instruction and interaction.
    f. Mobile device control of system volume levels, Activate Pod selection, and advanced system settings.

13. Activate Pods with 2-way audio communication featuring the following functionality:
    a. Integrated speaker and microphone to enable 2-way communication between the teacher and each small group.

b. Wireless audio communication and battery power for maximum portability.
c. Up to 12 speaker Pods can be connected to Topcat for each small student group.
d. Enables student sharing directly from the Pods so students can be clearly heard by the whole class.
e. Must include a call button allowing students to notify the teacher when they need assistance.

B. The amplifier must contain a 25/70V page mute function (PageFirst™) that passively detects the audio signal of a page coming through the 25/70V PA system without compromising system performance or voiding warranties. As an audio signal is sent to the PA speaker, the PageFirst™ detects that signal and immediately mutes the Topcat audio amplifier.

C. The amplifier must contain a contact closure input connection to detect a signal from Fire Alarm, IP Paging System or other device and mutes all amplifier audio to ensure emergency alerts from external systems can be heard clearly.

D. The amplifier must contain a contact closure output to interface with external alert notification system, enabling an alert to be triggered by the teacher microphone with a button press.

E. The system must produce high speech intelligibility and full-range multimedia quality sound with excellent distribution throughout a classroom.

F. The system must be capable to be installed in a classroom with no wires installed in or on the walls. The system must be fully operational without speaker wires or sensor cables.

G. The system must be compatible and expandable to operate with 2-way small group speaker Pods allowing interoperability between both small group and whole group instruction.

H. The system shall carry a standard warranty equivalent to the Lightspeed 5-year Warranty.

2.4 IN-CEILING CLASSROOM AUDIO SYSTEM SPECIFICATIONS

A. Furnish and install in-ceiling classroom audio system at each location shown on the drawings.

B. Features:

1. Power output: 20 Watts RMS
2. Acoustic Frequency response: 60 Hz to 18 kHz -10dB
3. AC Mains Power Input: 100-240V ~ 50/60Hz 1.5A
4. DC Power Input: 24V/2.5A
5. Signal-to-noise: 60 dB
6. Total Harmonic Distortion: <1%, 10 W
7. Wireless Communication: Access Technology (1.9 GHz)
8. Automatic power on when Flexmike is powered on and linked
9. Dimensions (W x D x H): 24” x 12” x 3.7” (Removable side spacers to fit international ceiling grids; 595mm x 295mm x 94mm)
10. Weight: 13.5 lbs. (6.1 kg)
11. Controls:
    a. (1) Tone control
    b. (1) Audio input volume control
    c. (1) PageFirst sensitivity adjustment

12. Connections:
    a. (1) Direct AC mains power input
    b. (1) Optional DC Power Input
    c. (1) Audio input (Longer cable runs may require a ground loop isolator in order to prevent audio hum caused by a ground loop.)
    d. (1) Audio in from another Topcat
    e. (1) Audio out to another Topcat
    f. 6-pin euro-block system interface with:
        1) 24/70V page-sensing mute (PageFirst™)
        2) Contact closure input mute
        3) Contact closure output trigger

13. Wireless audio range: up to 200 feet
14. Integrated 2-Way Hybrid Speaker System:
    a. Description: exciter technology sound panel plus low frequency cone driver
    b. Integrated cross-over technology
    c. Panel Size: 13.75” x 6.75”
    d. Cone Driver Size: 5.25”
    e. Overall Frequency Response: 60 Hz to 18 kHz -10dB
    f. Impedance: 8 Ω
    g. Power Handling: 25 W

C. The in-ceiling classroom audio system shall use bi-directional wireless Access Technology to communicate with up to three wireless microphones.

D. The in-ceiling classroom audio system shall use bi-directional wireless Access Technology to integrate with other audio sources in the classroom.

E. The in-ceiling classroom audio system shall use bi-directional wireless Access Technology to send a mixed audio output to a media connector or Activate Station located at a convenient/student accessible location in the classroom.

F. The in-ceiling classroom audio system shall use bi-directional wireless Access Technology to communicate with up to 12 optional tabletop speaker Pods available to facilitate small group instruction.

G. The all-in-one system must contain a Page mute function (PageFirst™) that passively detects the audio signal of a page coming through the PA system without compromising system performance or voiding warranties. As an audio signal is sent to the PA speaker, the PageFirst passive sensor clip detects that signal and immediately mutes the Topcat.

H. The amplifier must contain a contact closure input connection to detect a signal from Fire Alarm, IP Paging System or other device and mutes all amplifier audio to ensure emergency alerts from external systems can be heard clearly.

I. The amplifier must contain a contact closure output to interface with external alert notification system, enabling an alert to be triggered by the teacher microphone with a button press.

2.5 FLEXMIKE PENDANT-STYLE MICROPHONE / TRANSMITTER

A. Furnish and install two (2) Flexmike pendant-style wireless microphones at each in-ceiling instructional audio system.

B. Features:

1. Description: the pendant-style Flexmike transmitter shall contain microphone volume control on the unit allowing users to adjust volume level from anywhere in the classroom. The Flexmike shall be capable of being worn around a teacher's neck as a hands-free microphone via the lavaliere cord or to be used as a handheld student pass-around microphone. The Flexmike must be rechargeable via cradle charger or USB power. It must have a user replaceable, snap-in rechargeable battery pack.
2. Lanyard: adjustable length with magnetic clasp
3. Wireless communication: Access Technology (1.9 GHz)
4. Transmission range: up to 200 ft (60m)
5. Audio distortion: <1%
6. Integrated microphone type: uni-directional electret
7. Digital audio interface: USB-C 2-way digital audio interface
8. Earbud output: 3.5mm (for monitoring optional Activate Pods)
9. Push button volume control: +/- 6dB (total range = 12 dB)
10. Power: on/off/mute button
11. Battery Power: 3.7V Li-Ion battery pack
12. Battery run time: 8 hours (fully charged)
13. Charging: via cradle charger or USB-C cable
14. Cradle Charger: 2-slot drop-in cradle charger capable of charging 2 microphones
15. Cradle Charger Power: 5V USB-C, charging off AC power or computer USB
16. Pairing: IR emitter to enable one-button pairing with amplifier
17. Dimensions (L x W x H): 2.9" x 1.1" x 0.7" (74 x 28 x 18mm)
18. Weight: 1.2 oz (34g)

2.6 ACTIVATE CHARGING STATION WITH ACCESS TECHNOLOGY, BLUETOOTH AND WIRELESS MEDIA CONNECTIVITY

A. Furnish and install one (1) Activate Charging base with built-in Bluetooth and Media Connector for each in-ceiling instructional audio system speaker.

B. Integration with Activate mobile app for control, streaming and audio/video recording of classroom instruction and interaction.

C. Mobile device control of system volume levels, Activate Pod selection, and advanced system settings.

D. Mobile app functionality: Bluetooth interface with companion mobile application with the following functionality:

1. Control and connect to small group 2-way audio Pods
2. Adjust system audio levels and tone control
3. Mobile device audio streaming from audio books, podcasts, music, etc.
4. Audio/video recording synched with microphone and Pod audio

E. Features:

1. Wireless Communication: Access Technology (1.9 GHz + RF4CE), Bluetooth audio (2 channels), Bluetooth LE (2 channels)
2. Wireless range: Up to 200 ft. (60m) from Topcat, up to 100 ft. (30m) from mobile device.
3. Audio frequency response: 80 Hz to 7 kHz □3 dB
4. Audio distortion: <1%

5. Cradle charging: 2 Flexmikes; 8 Pods
6. USB charging ports: Two (2) 5V/0.3A charging for Pods; Two (2) 5V/1.0A charging for mobile devices or Pods.
7. DC Power Input: 24V/1.75A
8. Auxiliary Power Input: 5V USB-C from portable power source (no device charging)
9. Audio Inputs: (4) 3.5mm stereo jacks with volume control
10. Bluetooth Audio: (2) independent 2-way Bluetooth audio channels
11. Audio Outputs: (2) 3.5mm jack with volume control
12. Volume controls: Audio input, tone, audio output with 10-segment level indicator
13. Device Pairing: (2) Push buttons for Bluetooth device pairing, (1) push button for Access device registration.
14. Mounting: table-top
15. Dimensions (W x D x H): 13.3”x 5.9”x 1.9” (340 x 150 x 52mm)
16. Weight: 1.85 lbs. (0.84kg)

2.7 2-WAY AUDIO PODS FOR SMALL GROUPS

A. Furnish and install (6) 2-way audio pods for each space with in-ceiling instructional audio system.

B. Features:

1. Description: 2-way audio Pod with integrated speaker and microphones. Up to 12 Pods can be connected to a single audio system.
2. Wireless Communication: Access Technology (1.9 GHz)
3. Wireless range: Up to 200 ft. (60m) from Topcat; up to 100 ft. (30m) with walls
4. Integrated speaker: 1” high output speaker
5. Power output: 1 Watt per Pod speaker
6. Integrated microphones: Two (2) Omni-directional electret with noise rejection
7. Headphone output: 3.5mm
8. Controls: Power on/off button, volume up/down buttons, teacher call button
9. Battery power: 2.5V NiMH rechargeable battery pack
10. Battery charging: 2 contact for cradle charging + 5V/0.3A micro-USB
11. Battery life: 10+ hours (fully charged)
12. Dimensions: 5.2” x 2.1” 1.1” (132 x 54 x 28mm)
13. Weight: 6.4 oz. (181g)

2.8 INTEGRATING THE TOPCAT WITH OTHER AUDIO SOURCES

A. The wireless Media Connector must have four audio inputs to allow other audio sources to be wirelessly transmitted and played through the Topcat system. Computers, DVD/VCR’s, TV’s, CD’s, MP3’s etc. may be connected into the Media Connector using appropriate patch cords. The Media Connector must also receive audio back from the Topcat to output the mixed audio signal of both microphone channels and multimedia for recording purposes and interface with assistive listening devices. See drawings for requirements.

B. The Topcat system vendor will furnish and install 3.5MM stereo input cable from the projector audio out to the Topcat speaker.

2.9 INTEGRATING THE TOP CAT WITH PUBLIC ADDRESS SYSTEM

A. The Topcat system vendor will make termination of the two-conductor cable from the public address (PA) system speaker to the Topcat speaker for PA override. Coordinate requirements with the PA system vendor.

B. A teacher can use their Lightspeed Flexmike microphone to send an alert through the building's public address system. A Contact Closure on the Lightspeed Topcat system is a normally open relay that can be closed by pressing the up and down volume buttons at the same time for 3 seconds on the Flexmike. This activates the contact closure function on the Topcat, which external systems use to perform a prescribed action, such as notifying the appropriate parties of a classroom alert.

2.10 The Topcat system vendor will make termination of the cable from the public address (PA) system emergency call station input. Coordinate requirements with the PA system vendor.

2.11 INTEGRATING WITH LOCAL SOUND SYSTEM

A. Furnish and install Lightspeed Access Link in Band E157, Chorus E151 and Large Group Seminar E230. The Light Access Link shall enable the local sound system in these rooms shall enable 2-way collaborative audio for student sharing and small group learning.

B. Furnish and install (1) Active Charging Station, (2) Flexmike's and (6) 2-way audio pods in each space.

2.12 REGULATORY AND CERTIFICATIONS

A. The classroom audio system and its components shall be manufactured using lead-free processes and free of other materials harmful to the environment (RoHS and WEEE compliant).

B. The classroom audio system and its components shall be listed to UL/CUL standards and requirements for electrical safety by Underwriters Laboratories Inc.

C. The classroom audio system must be suitable for use in air handling spaces and carry appropriate certifications (UL 2043).

D. The classroom audio system and its components shall be CE Certified and conform with the essential requirements of the following European Union Directives: 2014/30 EU Electromagnetic Compatibility (EMC), 2014/35/EC Low Voltage Directive (LVD) and RED 2014/53EU.

E. The classroom audio system and its components shall comply with Part 15 of the FCC rules as a Class B digital device (FCC Certified).

PART 3 - EXECUTION

3.1 SYSTEM PERFORMANCE

A. Install in accordance with Manufacturer's installation instructions.

B. Final adjustment: Upon completion, the system shall be clean, adjusted and left in perfect operating condition. Transmitters shall be plugged in and charging and Daily Use Guide should be left in a conspicuous place. The full user manual shall be available for download from the manufacturer's website.

C. Provisions: There shall be no audible components of hum, noise, or distortion.

3.2 INSTALLATION

A. The ceiling cavity is being used as plenum return. Provide plenum rated cables, conduit, backboxes in all plenum rated ceilings, rated walls, penetrations though wall, floors and ceilings and where required by Local, State or Federal Codes.

B. Provide and install in-ceiling classroom audio system at the locations shown on drawings as required.

C. All equipment and enclosures described in this specification shall be permanently attached to the structure and held firmly in place. Supports shall be adequate to support their loads per manufacturers specifications.

D. The process of testing the Audio Sound System may necessitate moving and adjusting certain component parts (ex. loudspeakers). Contractor shall provide at no additional cost to the owner.

E. Take precautions as necessary to prevent and guard against electromagnetic and electrostatic noise interference. Long cable runs, unshielded and / or poorly shielded cable, multiple ground paths and improper grounding may all contribute to the production of a low frequency hum. In most cases a ground loop isolator (not provided) placed in line will attenuate or possibly eliminate the hum.

F. Wireless Media Connector to be located per Owner's request. Contractor to ensure all Media Connectors are properly registered and all volume controls are set properly via a field test in every classroom. Ensure power is available for Media Connector.

G. Activate Charging Station shall be located per Owner's request. Contractor to ensure all Media Connectors or Activate Charging Stations have power available, are properly registered, and all volume controls are set properly via a field test in every classroom.

H. System wiring shall be in accordance with good engineering practices as established by the EIA and NEC. Wiring hall meet all established state and local electrical codes. All wiring shall test free from grounds and shorts. Complete system shall be installed in strict accordance with manufacturer's recommendations.

I. Install wiring in conduit and raceways except as indicated.

J. Conceal wiring installations where possible.

K. Cable Support: Securely fasten to the permanent building structure where not installed in raceway. Support at regular intervals appropriate to the cable and wire size. Cable and wiring shall not lay loose on ceiling tiles or grids. Install parallel to building lines and follow building structure. Use cable support equipment/hardware recommended by the manufacturer.

L. Cable Pulling: Do not exceed manufacturer's recommended pulling tensions. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between indicated

termination, tap, or junction points. Remove and discard cable where damaged during installation and replace it with new cable.

M. Wiring within Enclosures: Bundle, lace, and trim the conductors to terminal points with no excess. Provide and use lacing bars and distribution spools.

N. Identify and tag all cables with permanent type markers to denote location served.

O. Install and wire equipment in accordance with accepted engineering and installation practices. Only the highest degree of workmanship will be accepted.

P. Arrange equipment to facilitate access for maintenance and working space.

3.3 TOPCAT AUDIO INTEGRATION USING ACTIVATE STATION

A. The wireless Activate Station must have four audio inputs plus two Bluetooth audio channels to allow other audio sources to be wirelessly transmitted and played through the Topcat system. Computers, laptops, mobile devices, LCD displays, etc. may be connected into the Activate Station via Bluetooth or using the appropriate patch cable. The Activate Station must also receive audio back from the Topcat to output the mixed audio signal of both microphone channels as well as selected Pods for audio/video recording to the mobile device and interface with assistive listening devices. Activate Station must also communicate with mobile devices via Bluetooth LE for selection and control of small group audio Pods and system volume levels.

3.4 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup checks according to the approved manufacturer's written instructions.

3.5 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct two 4-hour training sessions. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

C. Conduct four 4-hour training sessions. Train teachers and administration personnel on system operation.

3.6 SPARE PARTS

A. Furnish the following component at the end of the project to the Owner:

1. Three (3) complete systems, each with:
   a. (1) In-ceiling classroom audio system
   b. (2) Flexmike microphones
   c. (1) Active charging station
   d. (6) 2-way audio pods

End of Section

Section 27 50 00

IN-BUILDING CELLULAR AMPLIFICATION SYSTEM

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. Section Includes:

1. Furnishing and installing a system complete in every respect and ready to operate. All miscellaneous items and accessories required for such installation, whether each such item or accessory as shown on the plans or mentioned in these specifications, shall be furnished, and installed.

B. Related Sections include the following:

1. Division 01 Section "General Commissioning Requirements."
2. Division 01 Section “Facility Exterior Enclosure Commissioning.

1.4 PROGRAMMING

A. Coordinate and obtain a written approval of system functionality from the Owner prior to programming.

B. Perform a walk-through with the Owner and demonstrate the system functionality.

C. Make any adjustments to system functionality after initial programming, if necessary, to achieve the desired functionality requested by the Owner. Coordinate all required reprogramming with the Owner as part of this contract.

D. Obtain a written final letter of acceptance from the Owner upon completion of system functionality programming and demonstration.

E. Upon completion of the installation, the owner will review the functionality of the installed system and compare to the minimum performance standards as set forth in these specifications. Any installed system not meeting the minimum standards of performance as set forth in these specifications will be removed by the providing Vendor and replaced with a system referred to in these specifications as the "standard system of reference" at the expense of the Vendor responsible for this section of the specifications. Any additional expenses incurred to meet the owner's interpretation of the "standard system of reference" will be the sole responsibility of the Vendor responsible for this section of the specifications. Any delays in the schedule shall also be subject to liquidated damages.

1.5 SUBMITTALS

A. Comply with the following:

1. The vendor shall submit certification letter from the manufacturer of submitted equipment certifying that the installer is an authorized and certified installer of the submitted equipment.
2. The vendor shall make all connections at all field devices and at the head-end; and shall make all necessary field adjustments for a fully functional system.

B. Shop Drawings

1. Prior to assembling or installing the system, the Contractor shall provide complete shop drawings which include the following:
   a. List the name of the manufacturer's local representative and his/her phone number.
   b. Table of contents.
   c. Manufacturer's parts lists
   d. Product serial numbers
   e. Catalog cut sheets
   f. Installation instructions
   g. Typical wiring diagrams
   h. Drawings showing equipment locations
   i. Manufacturer's warranty documents

2. All drawings shall be fully dimensioned.
3. Operating License: Submit evidence of application for FCC Radio Station Authorization prior to installing equipment when required for operation of the equipment.

C. As-Built Drawings

1. At the conclusion of the project, the Vendor shall provide "as built" drawings. The "as built" drawings shall be a continuation of the Contractors shop drawings as modified, augmented, and reviewed during the installation, check out and acceptance phases of the project. All drawings shall be fully dimensioned and prepared in DWG format using the latest version of AutoCAD.
2. The as-built drawings shall incorporate all updated system riser diagrams prepared in DWG format using the latest version of AutoCAD.

D. Manuals

1. At the conclusion of the project, the Vendor shall provide copies of the manuals as described herein. Each manual's contents shall be identified on the cover. The manual

shall include names, addresses, and telephone numbers of each system integrator installing equipment and systems and the nearest service representatives for each item of equipment for each system. The manuals shall have a table of contents and labeled sections. The manuals shall include all modifications made during installation, checkout, and acceptance. The manuals shall contain the following:

a. Hardware Manual
   1) The hardware manual shall describe all equipment furnished including:
   2) General description and specifications
   3) Installation and check out procedures
   4) Equipment layout and electrical schematics to the component level
   5) System layout drawings and schematics
   6) Alignment and calibration procedures
   7) Manufacturers repair parts list indicating sources of supply

b. Software Manual
   1) The software manual shall describe the functions of all software and shall include all other information necessary to enable proper loading, testing, and operation. The manual shall include:
   2) Definition of terms and functions
      a) Use of system and applications software
      b) Initialization, start up, and shut down
      c) Alarm reports
      d) Reports generation
      e) Data base format and data entry requirements
      f) Directory of all disk files

2. Operators Manual
   a. The operator's manual shall fully explain all procedures and instructions for the operation of the system including:
      1) Computers and peripherals
      2) System start up and shut down procedures
      3) Use of system, command, and applications software
      4) Recovery and restart procedures
      5) Use of report generator and generation of reports
      6) Data entry
      7) Operator commands
      8) Alarm messages and reprinting formats
      9) System access requirements

3. Maintenance Manual
   a. The maintenance manual shall include descriptions of maintenance for all equipment including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective components.

1.6 SYSTEM DESCRIPTION

A. Services: Upon commissioning, the In Building cellular amplification system shall provide coverage for the WSPs listed below on all frequencies currently being used by the designated WSPs in the given market that has an exterior signal level is -70db or stronger.

1. AT&T
2. Sprint
3. T-Mobile
4. Verizon

5. US Cellular

Service	Downlink
Cellular	870 - 894
PCS	1930 - 1995
AWS	2110 - 2155
700 LTE	728 - 756

B. WSP Notification: The Contractor shall register the amplifiers with the WSP's on their web sites that the amplifiers will be connected to the WSPs' macro networks.

1.7 CODES, STANDARDS AND CERTIFICATIONS

A. All work, including but not limited to cabling, pathways, support structures, wiring, equipment, installation, workmanship, maintenance and testing shall comply with the latest editions of the National Electrical Code, National Electrical Safety Code, all applicable local rules and regulations, equipment manufacturer's instructions, and the National Electrical Contractors Association (NECA) Standard of Installation. In case of discrepancy or disagreement between the documents noted above, the contractor shall satisfy the most stringent requirements.

B. It is the Contractor's responsibility to ensure that the components comply with local code, ordinances or requirements established by the AHJ.

1.8 ABBREVIATIONS AND ACRONYMS

A. AHJ: Authority Having Jurisdiction

B. ATP: Acceptance Test Plan

C. AWS: Advanced Wireless Service

D. BDA: Bi-Direction Amplifier

E. BOM: Bill-of-Material

F. DAS: Distributed Antenna System

G. DAQ: Digital Audio Quality

H. ESMR: Enhanced Specialized Mobile Radio

I. FCC: Federal Communications Commission

J. iDEN: Integrated Enhanced Digital Network

K. LMR: Land Mobile Radio

L. LTE: Long Term Evolution

M. MTBF: Mean Time Between Failure

N. NFPA: National Fire Protection Association

O. NMS: Network Management System

P. PCS: Personal Communications System

Q. PSN: Public Safety Network

R. RoF: Radio-over-Fiber

S. RoHS: Restriction of Hazardous Substances

T. RSL: Received Signal Level

U. SISO: Single-Input, Single-Output

V. SMR: Specialized Mobile Radio

W. SMS: Short Message Service

X. SNMP: Simple Network Management Protocol

Y. SOW: Statement of Work

Z. VSWR: Voltage Standing Wave Ratio

AA. WSP: Wireless Service Provider

1.9 DEFINITIONS

A. Acceptance: Expressed approval by the customer

B. Active: Components that require AC/DC power for operation

C. Channel: A path for an RF transmission between two points

D. Component: A main system element of the Amplification system

E. Contractor: The prime contractor bidding the project

F. Delivered Audio Quality (DAQ): A measure of audio quality over a transmission medium used to quantify the quality of audio heard over a radio system. DAQ levels are defined by the following scale:

1. DAQ 1: Unusable. Speech present but not understandable.
2. DAQ 2: Speech understandable with considerable effort. Requires frequent repetition due to noise or distortion.
3. DAQ 3: Speech understandable with slight effort. Requires occasional repetition due to noise or distortion.
4. DAQ 3.4: Speech understandable without repetition. Some noise or distortion present.
5. DAQ 4: Speech easily understandable. Little noise or distortion.
6. DAQ 5: Perfect. No distortion or noise discernible.

G. Sub-contractor: A qualified and experienced integrator performing the deployment for the Contractor.

H. Head-End Equipment: The equipment that accepts the RF Source, and then typically amplifies the RF source to the interior antennas.

I. Passive: Components that do not require AC/DC power for operation

1.10 PERFORMANCE REQUIREMENTS

A. On a per channel basis, the downlink RSL for each frequency band shall meet or exceed the criteria in Table 1.

Table 1. System Parameters

Parameters	Unit	700 LTE	Cellular, PCS, AWS, Commercial 800 MHz
Minimum downlink receive signal level (RSL)	dBm	-75	-85

B. Contractor shall state the assumed channel loading and frequency bands for the proposed WSP in-building coverage. Prior to installation, contractors shall confirm the channel loading and frequency use in the serving area and shall guarantee coverage for these channels per the criteria in Table 1.

C. The system shall deliver coverage per the criteria in Table 1 throughout 95% of the building.

1.11 WARRANTY

A. Comply with Section 260001.

B. The Electrical Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers

1. Wilson Electronics.
2. SureCall.
3. HiBoost.
4. Or approved equal.

2.2 BASIS OF DESIGN

A. The system specified is based upon products by Wilson Electronics; and represents the performance standard upon which any equivalent solution shall be based.

PART NO.	DESCRIPTION
460152	Enterprise 4300 rack mounted, multi-amplifier cell booster
460149	Enterprise 1300 rack mounted, amplifier cell booster
304412	4G LTE/3G High Performance Wide-Band Dome Ceiling Antenna (for surface and hard ceiling installation)
314406/314407	4G Low-Profile Dome Antenna (for suspended ceiling installation)
311155	70-degree directional cellular antenna for hallways and large rooms. (for wall mount)
859981	4-Way Splitter
859980	3-Way Splitter
859957	2-Way Splitter
859907	Tap -10 dB
859114	Tap -7 dB
314411/314475	Outdoor 50 Ohm Wide Band Directional Antenna
971109	N-Male Crimp Connectors
Wilson400	Low Loss Cable
	1.5” x 10 ft. Aluminum pole with mounting accessories. Cut pole to length in the field.

2.3 GENERAL

A. The system shall be completed with all components and wiring required for compliance with all applicable codes and regulations, and for its operation as described hereinafter. No exclusion from or limitation in the symbolism used on the drawings or the language used in these specifications shall be interpreted as a reason for omitting any appurtenances or accessories required to enable the system to perform the specified functions.

B. Upon completion of the installation, the work shall include making all arrangements with the owner’s project manager and providing any assistance necessary for inspection and test for a fully functional system. In conjunction with the above, training as deemed necessary to instruct authorized building personnel in the proper operation of the system shall also form a part of the required work.

C. The site and the building shall be both pre and post tested for signal strength. This Contractor shall employ the services of an integrator to perform the signal strength. Any expense incurred by the test shall be the responsibility of this Contractor.

D. The integrator shall have experience in the design and installation of In-Building Cellular Amplification System and is expected to perform a site survey to determine the signal strength

on and near the building grounds to ascertain the level of amplification necessary to provide clear and reliable cellular reception in all occupiable areas inside the building.

E. The test shall check the signal reception in several locations on the floor area. Signal strength shall be for clear reception throughout the building utilizing cellphones from various providers.

2.4 COMPONENTS

A. Cellular Amplifiers

B. Single Output Amplifier

C. Single Input Single Output (SISO) wall mount or rack mount cellular amplifier shall provide up to +15 dBm downlink power with maximum of 70dB gain that is compatible with all North American cell networks

D. The cellular amplifier shall incorporate eXtended Dynamic Range (XDR) ® technology to protect the amplifier from shutting down due to a strong outside signal (-40dBmor higher)or changes in the outside signals.

E. The cell amplifier shall auto-detect and prevent any cell tower interference.

F. The cell amplifier shall be procured in kits per FCC regulations. The minimum kit shall include (1) cell amplifier, (1) outside Directional Antenna, (1) Inside Dome Antenna, (1) Lightning surge protector (1) 2’ low loss LMR 400 cable, 75’ Low loss LMR 400 cable, (1) 100’ low loss LMR 400 cable

G. Frequencies:

1.	Band 12	700MHz
2.	Band 13	700MHz
3.	Band 5	850MHz
4.	Band 4	1700/2100MHz
5.	Band 25/2	1900MHz

2.5 MULTIPLE OUTPUT AMPLIFIER

A. Single Input Multiple Output (SIMO) wall mount or rack mount cellular amplifier shall provide up to +12 dBm downlink power with maximum of 70dB gain from the input to each of (4) outputs and is compatible with all North American cell networks

B. The cellular amplifier shall incorporate eXtended Dynamic Range (XDR) ® technology to protect the amplifier from shutting down due to a strong outside signal or changes in the outside signals.

C. The cell amplifier shall auto-detect and prevent any cell tower interference.

D. The cell amplifier shall be procured in kits per FCC regulations. The minimum kit shall include (1) cell amplifier, (1) outside Directional Antenna, (1) Inside Dome Antenna, (1) Lightning surge protector (1) 2’ low loss LMR 400 cable, 75’ Low loss LMR 400 cable, (1) 100’ low loss LMR 400 cable

E. Frequencies:

1. Band 12 700MHz
2. Band 13 700MHz
3. Band 5 850MHz
4. Band 4 1700/2100MHz
5. Band 25/2 1900MHz

2.6 OUTSIDE ANTENNAS

A. Omni-Directional Outside Antennas: Omni-Directional outside antennas shall feature a multi-band design, accommodating multiple frequency bands in a single small antenna.

1. Electrical Band 1:
   a. Frequency Band: 698 – 800 MHz
   b. VSWR: < 1.8
   c. Gain: 2 dBi
   d. Maximum input power:100W
   e. Impedance: 50 Ω
   f. Beamwidth, Horizontal: 360° omnidirectional
   g. Beamwidth, Vertical: 60° nominal

2. Electrical Band 2:
   a. Frequency Band: 1710 – 2700 MHz and 800 – 960 MHz
   b. VSWR: 1.5:1
   c. Gain: 5 dBi
   d. Maximum input power: 100W
   e. Impedance: 50 Ω
   f. Beamwidth, Horizontal: 360° omnidirectional
   g. Beamwidth, Vertical: 60° nominal

3. Mechanical:
   a. Connector: 50 Ω N Type Female
   b. Mounting: Mast Mount
   c. Radome material: ABS, UV resistant
   d. Pigtail cable: KSR195, plenum rated

4. Environmental:
   a. Application: Outdoor
   b. Operating Temperature: 40 °C to +60 °C (40 °F to +140 °F)
   c. Relative Humidity: Up to 100%

5. Regulatory Compliance/Certifications: RoHS 2002/95/EC

B. Outside Directional Antennas (YAGI): Outside Directional antennas shall feature a multi-band design, accommodating multiple frequency bands in a single small antenna.

1. Electrical Band 1:
   a. Frequency Band: 698 – 800 MHz
   b. VSWR: < 1.8
   c. Gain: 2 dBi
   d. Maximum input power:100W
   e. Impedance: 50 Ω
   f. Beamwidth, Horizontal: 360° omnidirectional
   g. Beamwidth, Vertical: 60° nominal

2. Electrical Band 2:
   a. Frequency Band: 1710 – 2700 MHz and 800 – 960 MHz
   b. VSWR: <1.8
   c. Gain: 4 dBi
   d. Maximum input power: 100W
   e. Impedance: 50 Ω
   f. Beamwidth, Horizontal: 360° omnidirectional
   g. Beamwidth, Vertical: 60° nominal

3. Mechanical:
   a. Connector: 50 Ω N Type Female
   b. Mounting: Thru-hole ceiling mount
   c. Radome material: ABS, UV resistant
   d. Pigtail cable: KSR195, plenum rated

4. Environmental:
   a. Application: Indoor
   b. Operating Temperature: 40 °C to +60 °C (40 °F to +140 °F)
   c. Relative Humidity: Up to 100%

5. Regulatory Compliance/Certifications: RoHS 2002/95/EC

2.7 INSIDE ANTENNAS

A. Omni-Directional Coverage: Omni-Directional Coverage antennas shall feature a multi-band design, accommodating multiple frequency bands in a single small antenna.

1. Electrical Band 1:
   a. Frequency Band: 698 – 800 MHz
   b. VSWR: 1.5:1
   c. Gain: 7 dBi
   d. Maximum input power: 50 watts
   e. Impedance: 50 Ω
   f. Beamwidth, Horizontal: 360° omnidirectional
   g. Beamwidth, Vertical: 60° nominal
   h. Return Loss: 10.9 dB

2. Electrical Band 2:
   a. Connector: 50 Ω N Type Female
   b. Mounting: Thru-hole ceiling mount
   c. Radome material: ABS, UV resistant
   d. Pigtail cable: KSR195, plenum rated

3. Mechanical:
   a. Connector: 50 Ω N Type Female
   b. Mounting: Thru-hole ceiling mount
   c. Radome material: ABS, UV resistant
   d. Pigtail cable: KSR195, plenum rated

4. Environmental:
   a. Application: Indoor
   b. Operating Temperature: 40 °C to +60 °C (40 °F to +140 °F)
   c. Relative Humidity: Up to 100%

5. Regulatory Compliance/Certifications: RoHS 2002/95/EC

B. Low Profile Omni-Directional Coverage: Omni-Directional Coverage antennas shall feature a multi-band design, accommodating multiple frequency bands in a single small antenna.

1. Electrical Band 1:
   a. Frequency Band: 698 – 800 MHz
   b. VSWR: 1.5:1
   c. Gain: 7 dBi
   d. Maximum input power: 50 watts
   e. Impedance: 50 Ω
   f. Beamwidth, Horizontal: 360° omnidirectional
   g. Beamwidth, Vertical: 60° nominal
   h. Return Loss: 10.9 dB

2. Electrical Band 2:
   a. Frequency Band: 1710 – 2700 MHz and 800 – 960 MHz
   b. VSWR: 1.5:1
   c. Gain: 7 dBi
   d. Maximum input power: 50 watts
   e. Impedance: 50 Ω
   f. Beamwidth, Horizontal: 360° omnidirectional
   g. Beamwidth, Vertical: 65° nominal
   h. Return Loss: ≤ 13.9 dB

3. Mechanical:
   a. Connector: 50 Ω N Type Female
   b. Mounting: Thru-hole ceiling mount
   c. Radome material: ABS, UV resistant
   d. Pigtail cable: KSR195, plenum rated

4. Environmental:
   a. Application: Indoor
   b. Operating Temperature: 40 °C to +60 °C (40 °F to +140 °F)
   c. Relative Humidity: Up to 100%

5. Regulatory Compliance/Certifications: RoHS 2002/95/EC

C. Directional Coverage Antennas: Directional coverage antennas shall feature a multi-band design, accommodating multiple frequency bands in a single small antenna.

1. Electrical Band 1:
   a. Frequency Band: 698 – 800 MHz
   b. VSWR: 1.5:1
   c. Gain: ≥ 5.0 dBi @ 698 – 800 MHz
   d. Maximum input power: 50W
   e. Impedance: 50 Ω
   f. Beamwidth, Horizontal: 70/60°
   g. Polarization: Vertical
   h. Return Loss: ≤ 10.9 dB

2. Electrical Band 2:
   a. Frequency Band: 1710 – 2700 MHz and 800 – 960 MHz
   b. VSWR: ≤ 1.5:1

c. Gain: ≥ 5.0 dBi @ 800 – 960 MHz and ≥ 8.0 dBi @ 1710 – 2170 MHz
d. Maximum input power: 50W
e. Impedance: 50 Ω
f. Beamwidth, Horizontal: 70/60°
g. Return Loss: ≤ 13.9 dB

3. Mechanical:
   a. Connector: 50 Ω N Type Female
   b. Mounting: 4-hole wall mounting plate
   c. Radome material: ABS, UV resistant
   d. Pigtail cable: RG58, plenum rated

4. Environmental:
   a. Application: Indoor
   b. Operating Temperature: 40 °C to +60 °C (40 °F to +140 °F)
   c. Relative Humidity: Up to 100%

5. Regulatory Compliance/Certifications: RoHS 2002/95/EC

D. Air Dielectric, Plenum Rated Cable:

1. Material Characteristics:
   a. Jacket: Halogenated, Fire-Retardant
   b. Outer Conductor Material: Corrugated Aluminum or Corrugated Copper
   c. Inner Conductor Material: Copper-Clad Aluminum Wire

2. Electrical Characteristics:
   a. Impedance: 50 ± 2.0 Ω
   b. Frequency Band: 1 - 8800 MHz
   c. Peak Power Rating: ≥ 40.0 kW

3. Mechanical Characteristics:
   a. Diameter Over Jacket: ≤ .627 in
   b. Minimum Bending Radius: ≤ 5 in
   c. One Time Minimum Bending Radius: ≤ 3 in

4. Attenuation Characteristics:

Frequency (MHz)	Attenuation (dB/100ft)
150	≤ 0.848
450	≤ 1.53
800	≤ 2.105
2000	≤ 3.564

Standard Conditions: VSWR 1.0, ambient temperature 20 °C (68 °F)

E. Foam Dielectric Cable:

1. Material Characteristics:
   a. Jacket: Non-halogenated, Fire-Retardant Ployolefin
   b. Outer Conductor Material: Corrugated Copper
   c. Inner Conductor Material: Copper-Clad Aluminum Wire or Copper Tube

2. Electrical Characteristics:
   a. Impedance: 50 ± 1.0 Ω
   b. Frequency Band: 1/2" Nominal: 1 - 8800 MHz, 7/8" Nominal: 1 - 5000 MHz
   c. Peak Power Rating: ≥ 40.0 kW

3. Mechanical Characteristics:
   a. Diameter Over Jacket: 1/2" Nominal: ≤ .630 in, 7/8" Nominal: ≤ 1.1 in
   b. Minimum Bending Radius: 1/2" Nominal: ≤ 5 in, 7/8" Nominal: ≤ 10 in
   c. One Time Minimum Bending Radius: 1/2" Nominal: ≤ 2 in, 7/8" Nominal: ≤ 5 in

4. Attenuation Characteristics: 1/2" Nominal

Frequency (MHz)	Attenuation (dB/100ft)
150	≤ 0.815
450	≤ 1.447
800	≤ 1.968
2000	≤ 3.251

Standard Conditions: VSWR 1.0, ambient temperature 20 °C (68 °F)

5. Attenuation Characteristics: 7/8" Nominal:

Frequency (MHz)	Attenuation (dB/100ft)
150	≤ 0.417
450	≤ .744
800	≤ 1.014
2000	≤ 1.683

Standard Conditions: VSWR 1.0, ambient temperature 20 °C (68 °F)

F. Splitters, Taps, Couplers, and Coax Jumpers:

1. Approved Manufacturer: Wilson Electronics

PART 3 - EXECUTION

3.1 INSTALLATION

A. The contractor shall install, commission, and test the Cellular amplification system in accordance with the manufacturer's instructions and recommendations.

B. The contractor shall install the Cellular amplification system in accordance with the accepted SOW.

C. The contractor shall adhere to all work and safety requirements while working at the job site.

D. The contractor shall have Cellular amplification system project foreman on site overseeing the installation.

E. The contractor shall have at a minimum one Project Manager on staff overseeing the project. The Project Manager will be responsible for the following:

1. Developing and maintaining a project plan consistent with the overall milestones of the project.
2. Overseeing and coordinating the activities of the Cellular amplification system project, including: initiating and holding weekly project conference calls, as well as maintaining and distributing meeting minutes.
3. Act as the point-of-contact interface for all Cellular amplification system project activities.
4. Provide weekly status updates regarding work performed, worked scheduled, open items, problems/issues and resolutions.

F. The contractor and Sub-contractor shall be prepared to deploy the Cellular amplification system in a phased approached as dictated by the building construction and/or work of other trades.

G. The contractor and Sub-contractor shall facilitate WSP registration and connection to their respective macro networks.

H. The contractor and Sub-contractor shall be prepared to connect to the WSP's network(s) in a phased approached as dictated by the construction schedules.

I. Install cabling designed for the environment the cable will be installed in.

J. Terminate and test all cabling with a sweep analyzer.

K. Label all cabling per the contract drawings to indicate the segment number from each amplifier.

L. Provide exterior cell measurements according to the manufacturer's recommendations.

3.2 ACCEPTANCE TESTING

A. Acceptance testing will be performed confirming the requirements of Section 1.07 have been met.

B. The contractor shall complete the acceptance testing per the requirements and as prescribed in the approved Acceptance Test Plan (ATP) submittal.

C. Acceptance Testing

1. Acceptance Testing shall comply with the following:
   a. The Acceptance Test shall ensure that two-way coverage on each floor of the building meets the minimum coverage requirements detailed in Section 1.07.
   b. Tests shall be made using the frequencies listed in Section 1.02.A.
   c. Testing shall be coordinated with the Customer and AHJ to ensure no undue interference to any building operations.
   d. All testing shall be done on frequencies authorized by the FCC.

2. Test Procedures
   a. The test plan shall ensure testing throughout the building. Testing shall be performed on a grid system. A spot located approximately in the center of a grid area will be selected for the test. Once the spot has been selected, prospecting for a better spot within the grid area will not be permitted. A grid is overlaid onto a floor area to provide 20 grid cells. Grid cells are provided with definite minimum

and maximum dimensions. For most buildings, using a minimum grid dimension of 20 ft and a maximum grid dimension of 80 ft will suffice to encompass the entire floor area. A maximum of one area will be allowed to fail the test (95% coverage). Where a floor exceeds the sq ft, which is the floor area that can be covered by the system, the floor be subdivided into 40 equal sectors, with each sector being tested individually. A maximum of two non-adjacent areas will be allowed to fail the test (95% coverage). In addition to the above requirement, all critical areas, which include; the emergency command center(s), the fire pump room(s), exit stairs, exit passageways, elevator lobbies, standpipe cabinets, sprinkler sectional valve locations, and other areas deemed critical by the AHJ, shall be provided with 99 percent floor area radio coverage. Signal strength measurements shall be performed using standardized parameters as specified below.

3. Measurement Parameters
   a. Signal levels shall be measured to ensure the system meets the criteria specified in the Technical Proposal. Downlink measurements shall be made with the following standardized parameters:
      1) Measurements shall be recorded using a calibrated automatic signal-level measurement system measuring RSSI in each band with a dipole antenna positioned approximately 4’ above the surface.
      2) Measurements will be recorded for the test pattern as described above.
      3) System acceptance is achieved when 95% of the averaged data points meet or exceed the requirements specified here and in Section 1.07.

3.3 COMMISSIONING

A. Comply with requirements specified in Division 01.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup check according to the approved manufacturer's written instructions.

3.4 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct two 4-hour training sessions. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

End of Section

Section 27 50 10

HANDHELD RADIO AMPLIFICATION SYSTEM

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. It is the intent of these specifications that the Contractor, Manufacturer and/or its Authorized System Integrator expeditiously furnishes and installs a system complete in every respect and ready to operate. All miscellaneous items and accessories required for such installation, whether or not each such item or accessory as shown on the plans or mentioned in these specifications, shall be furnished and installed.

B. Upon completion of the installation, the owner will review the functionality of the installed system and compare to the minimum performance standards as set forth in these specifications. Any installed system not meeting the minimum standards of performance as set forth in these specifications will be removed by the providing Vendor and replaced with a system referred to in these specifications as the “standard system of reference” at the expense of the Vendor responsible for this section of the specifications. Any additional expenses incurred to meet the owner’s interpretation of the “standard system of reference” will be the sole responsibility of the Vendor responsible for this section of the specifications. Any delays in the schedule shall also be subject to liquidated damages as required and/or described in other sections of these specifications.

C. The school district has standardized on the Motorola 3500 handheld radios. This Contractor shall provide Motorola radio amplification infrastructure as shown on the contract documents and as specified herein.

1.4 PROGRAMMING

A. Coordinate and obtain a written approval of system functionality from the Owner prior to programming.

B. Perform a walk-through with the Owner and demonstrate the system functionality.

C. Make any adjustments to system functionality after initial programming if necessary to achieve the desired functionality requested by the Owner. Coordinate all required reprogramming with the Owner as required as part of this contract.

D. Obtain a written final letter of acceptance from the Owner upon completion of system functionality programming and demonstration.

1.5 SUBMITTALS

A. Comply with requirements specified in Division 01 and the following:

1. The vendor shall submit certification letter from the manufacturer of submitted equipment certifying that the installer is an authorized and certified installer of the submitted equipment.
2. The vendor shall make all connections at all field devices and at the head-end; and shall make all necessary field adjustments for a fully functional system.

B. Shop Drawings

1. Prior to assembling or installing the system, the Contractor shall provide complete shop drawings which include the following:
   a. List the name of the manufacturer's local representative and his/her phone number.
   b. Table of contents.
   c. Manufacturer's parts lists.
   d. Product serial numbers.
   e. Catalog cut sheets.
   f. Installation instructions.
   g. Typical wiring diagrams.
   h. Drawings showing equipment locations.
   i. Manufacturer's warranty documents.

2. All drawings shall be fully dimensioned.
3. Operating License: Submit evidence of application for FCC Radio Station Authorization prior to installing equipment when required for operation of the equipment.

C. As-Built Drawings

1. At the conclusion of the project, the Vendor shall provide "as built" drawings. The "as built" drawings shall be a continuation of the Contractors shop drawings as modified, augmented, and reviewed during the installation, check out and acceptance phases of the project. All drawings shall be fully dimensioned and prepared in DWG format using the latest version of AutoCAD.
2. The as-built drawings shall incorporate all updated system riser diagrams prepared in DWG format using the latest version of AutoCAD.

D. Manuals

1. At the conclusion of the project, the Vendor shall provide copies of the manuals as described herein. Each manual's contents shall be identified on the cover. The manual shall include names, addresses, and telephone numbers of each system integrator installing equipment and systems and the nearest service representatives for each item of equipment for each system. The manuals shall have a table of contents and labeled

sections. The manuals shall include all modifications made during installation, checkout, and acceptance. The manuals shall contain the following:

a. Hardware Manual
   1) The hardware manual shall describe all equipment furnished including:
   2) General description and specifications
   3) Installation and check out procedures
   4) Equipment layout and electrical schematics to the component level
   5) System layout drawings and schematics
   6) Alignment and calibration procedures
   7) Manufacturers repair parts list indicating sources of supply

b. Software Manual
   1) The software manual shall describe the functions of all software and shall include all other information necessary to enable proper loading, testing, and operation. The manual shall include:
   2) Definition of terms and functions
      a) Use of system and applications software
      b) Initialization, start up, and shut down
      c) Alarm reports
      d) Reports generation
      e) Data base format and data entry requirements
      f) Directory of all disk files

2. Operators Manual
   a. The operator's manual shall fully explain all procedures and instructions for the operation of the system including:
      1) Computers and peripherals
      2) System start up and shut down procedures
      3) Use of system, command, and applications software
      4) Recovery and restart procedures
      5) Use of report generator and generation of reports
      6) Data entry
      7) Operator commands
      8) Alarm messages and reprinting formats
      9) System access requirements

3. Maintenance Manual
   a. The maintenance manual shall include descriptions of maintenance for all equipment including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective components.

1.6 SYSTEM DESCRIPTION

A. Services: Upon commissioning, the handheld radio amplification system shall provide coverage for the Worcester Public School's (WPS) Motorola 3500 handheld radios. The radios shall be procured by WPS.

1.7 CODES, STANDARDS AND CERTIFICATIONS

A. All work, including but not limited to cabling, pathways, support structures, wiring, equipment, installation, workmanship, maintenance and testing shall comply with the latest editions of the National Electrical Code, National Electrical Safety Code, all applicable local rules and regulations, equipment manufacturer's instructions, and the National Electrical Contractors

Association (NECA) Standard of Installation. In case of discrepancy or disagreement between the documents noted above, the contractor shall satisfy the most stringent requirements.

B. It is the Contractor's responsibility to ensure that the components comply with local code, ordinances or requirements established by the AHJ.

1.8 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers

1. Motorola.

2.2 BASIS OF DESIGN

A. The system specified is based upon products by Motorola; and represents the performance standard upon which any equivalent solution shall be based.

2.3 GENERAL

A. The system shall be completed with all components and wiring required for compliance with all applicable codes and regulations, and for its operation as described hereinafter. No exclusion from or limitation in the symbolism used on the drawings or the language used in these specifications shall be interpreted as a reason for omitting any appurtenances or accessories required to enable the system to perform the specified functions.

B. Upon completion of the installation, the work shall include making all arrangements with the owner's project manager and providing any assistance necessary for inspection and test as required for a fully functional system. In conjunction with the above, training as deemed necessary to instruct authorized building personnel in the proper operation of the system shall also form a part of the required work.

C. The site and the building shall be both pre- and post-tested for signal strength. This Contractor shall employ the services of an integrator to perform the signal strength. Any expense incurred by the test shall be the responsibility of this Contractor.

D. The integrator shall have experience in the design and installation of In-Building Cellular Amplification System and is expected to perform a site survey to determine the signal strength on and near the building grounds to ascertain the level of amplification necessary to provide clear and reliable radio reception inside as well as outside the building covering the entire site.

2.4 COMPONENTS

A. Furnish and install the following equipment to provide handheld radio amplification on the interior as well as the exterior of the building.

DESCRIPTION
Motorola SL5700 UHF 50W Digital Repeater Includes: 403-470 MHz Operation, Two Time Slot TDMA Operation, IP Site Connect Functionality, 100% Duty Cycle, Internal Power Supply, UHF Duplexer, Duplexer Cables, Two Year Warranty
BRKT, Wall MT, SL5700
UHF Antenna System: Includes UHF Antenna, Transmission line, connectors, jumpers, and mounting hardware.
Licensing & Coordination FCC Include: 10-year license for Repeater frequencies Construction Filing Application Documentation FCC FRN Set up Digital Emissions
Install SLR5700 Digital Repeater. Program Owner furnished radios for Repeater Operation.

2.5 CONTRACTOR RESPONSIBILITIES

A. File handheld radio amplification system license with FCC. Carry licensing fees in the base bid.

B. Program repeater to FCC provided frequencies.

C. Program radios furnished by the Owner for site specific frequencies.

1. After radios are delivered to the school and the staff as taken occupancy, return to program 75 radios, including both new and existing radios.

PART 3 - EXECUTION

3.1 INSTALLATION

A. The contractor shall install, commission, and test the handheld amplification system in accordance with the manufacturer’s instructions and recommendations.

B. The contractor shall install the Cellular amplification system in accordance with the accepted SOW.

C. The contractor shall adhere to all work and safety requirements while working at the job site.

D. Install cabling designed for the environment the cable will be installed in.

E. Terminate and test all cabling with a sweep analyzer.

F. Label all cabling per the contract drawings to indicate the segment number from each amplifier.

3.2 ACCEPTANCE TESTING

A. Acceptance testing will be performed confirming the requirements of Section 1.07 have been met.

B. The contractor shall complete the acceptance testing per the requirements and as prescribed in the approved Acceptance Test Plan (ATP) submittal.

3.3 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup check according to the approved manufacturer's written instructions.

3.4 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct two 4-hour training sessions. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

C. Conduct two 4-hour training sessions. Train the Owner’s personnel on procedures related operation of the system.

End of Section

Section 27 51 16

PUBLIC ADDRESS SYSTEM

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. The contractor shall be responsible for providing a complete functional system, including all necessary components whether included in this specification or not.

B. The contractor shall provide the FCC registration number of the proposed system, where applicable.

C. The contractor shall supply and install all equipment, accessories, and materials in accordance with these specifications and drawings to provide a complete and operating IP-Based Communications System including but not limited to:

1. The platform shall employ state of the art IP Technology including the minimum functions listed.
   a. Intercom call between staff locations and classrooms with Unlimited Station capacity
   b. Interactive Facility Maps
   c. User customizable Announcements with priority
   d. Text-to-Speech Announcements
   e. Emergency Classroom Check-In can be used to enhances campus security
   f. Emergency or Normal Announcements are capable of being recorded and activated by a speed dial on an administrative console, DTMF, wireless panic button, mobile app, web browser or external IP networked system using HTTPS URL-based Application Programming Interface (API)
   g. Internal clock is synchronized with NTP network time server whether on the LAN, WAN or Internet keeping the Scheduled events (Bells) and Announcements accurate within milliseconds.
   h. Audio distribution allow for scheduled or manually activated audio to be activated from the Admin Web UI, contact closure, Admin phone and/or by use of Routines

i. Unlimited Schedules
j. Unlimited Time, Paging, and Audio Zones
k. Unlimited Page Stacking/Queueing
l. Unlimited Scheduled events
m. Unlimited Scheduled Audio events
n. Integrated Internet Radio Source
o. Email Notifications and Alerts the system can send an email with a system event, contact closure, or when a Routine has been activated to name a few
p. Supervised Station Status system can be setup to send an email when a Nyquist device goes offline.
q. Clock / Messaging Display capability improves school communications
r. Alert Filters – Allow facilities to monitor for such as weather events, earthquakes, tornados, tsunami, volcanoes, public health, power outages, and many other National Weather Alerts emergencies and warnings.
s. Multi-Site All Call paging allows authorized users to make normal district wide pages
t. Multi-Facility Emergency All-Call paging allows authorized users to make emergency district wide pages
u. Administrative Graphical User Interface or GUI that can be used by technicians or Administrative: CoS and Roles define who has access to what parts of the GUI
v. Push-to-Talk Microphone
w. Ambient Noise Sensing

2. The system shall have a Routines feature that allows staff to activate via Admin Web UI, dial string, panic button, mobile app, API or with an Admin phone touch interface. Routines can automatically launch a procedure, or sequence of actions, that the E7000 system executes as a result of an input trigger. Routines are designed with school security plans and can support crisis plans for situations such as school lockdown, weather events, or emergency evacuation.
3. Direct Inward Station Access or DISA allows administrator or first responder or emergency personnel with proper login codes to call into the system from outside the school into any classroom, zone, or entire facility with customer supplied SIP enabled Telephone Network. DISA is designed to allow remote monitoring, Facility All-Call or Zone Paging, and two-way conversation from outside the facility.
4. Authorized staff can use the Admin Web UI to configure the Clock/Messaging Display function. They can use it to create messages that will display on monitors connected to the 10-Watt plenum-rated Intercom Modules with HDMI 1.3 (max. 1920 x 1080 @ 24/30 Hz) output or the NQ-GA10PV devices in a selected zone, multiple zones, or to specific stations. When creating the message, you can set several options, including when and how long the messages are displayed, priority of messages, and the appearance of the messages. The schedule programming allows the event names to be displayed analog or digital clock along with day and date on an NQ-GA10PV Display. You can also remove messages from the message queue either manually or via a Routine.
5. The ADA requires that title II entities (State and local governments) and title III entities (businesses and nonprofit organizations that serve the public) communicate effectively with people who have communication disabilities. The goal is to ensure that communication with people with these disabilities is equally effective as communication with people without disabilities.
6. Interactive Facility Maps that are intuitive to use. Simply click on a classroom or area of the GUI and it can initiate an intercom, page or drill to another map level. I addition when the system is in Check-In mode the classroom has a pop up of a room's video feed via the Maps view if equipped. The system shall allow authorized staff to use the Map-based Audio/Video room monitoring during emergency check-in. Systems that don't have provisions for this are not considered equal.

7. In the event of wide area network or WAN outage every facility must be capable of operating standalone and allow for all features listed within this specification to work. Systems that rely on the WAN to operate shall not be considered for comparison in this bid.
8. Manage Check-In functionality that allows staff to quickly verify that they are aware that a check-in event is underway and are reporting classroom status for their assigned classrooms or areas. For staff to check-in all they have to do is press their Call Switch after they have completed their required check-in procedure. Examples of check-in events include but are not limited to weather related shelter-in-place, safety related lockdown, fire evacuation, room occupancy.
9. The E7000 has a Disable Audio feature that can be activated via contact closure from fire alarm or security system, Admin Web UI, dial string, panic button, mobile app., API or with an Admin phone touch interface. When the E7000 has its Audio Disabled the follow features are disabled: programmed or manually activated audio distribution, Zone Paging, normal announcement files, All-Call Paging, manual normal tones and scheduled event tones.
10. Optional password protection for multi-site emergency all-Call, multi-site all-call, facility page. Emergency all-call page, all-call page, emergency announcement, announcement, zone page, alarm, and tone are used to prevent unauthorized use of the system.
11. Text-to-Speech option allows Admin Web UI users to add custom announcements into the system by simply typing the text that you want converted to speech for this announcement. The system will then generate a .wav file that can be used by the E7000 system. Systems that don't offer Text-to-Speech options shall not be equivalent.
12. Installation Wizards are available for installers to reduce the setup time on major components in the system programming. Included wizards are as follows: Customer Information, Dialing Length, Station, User, Time Zone, Network Time Server, and Zones as a minimum.

1.4 PROGRAMMING

A. Coordinate and obtain a written approval of system functionality from the Owner prior to programming.

B. Perform a walk-through with the Owner and demonstrate the system functionality.

C. Make any adjustments to system functionality after initial programming to the satisfaction of the Owner, to achieve the desired functionality requested by the Owner. Coordinate all required reprogramming with the Owner as required as part of this contract.

D. Obtain a written final letter of acceptance from the Owner upon completion of system functionality programming and demonstration.

E. Upon completion of the installation, the owner will review the functionality of the installed system and compare to the minimum performance standards as set forth in these specifications. Any installed system not meeting the minimum standards of performance as set forth in these specifications will be removed by the providing Vendor and replaced with a system referred to in these specifications as the "standard system of reference" at the expense of the Vendor responsible for this section of the specifications. Any additional expenses incurred to meet the owner's interpretation of the "standard system of reference" will be the sole responsibility of the Vendor responsible for this section of the specifications. Any delays in the schedule shall also be subject to liquidated damages.

1.5 SUBMITTALS

A. Comply with requirements specified in Division 01 and the following:

1. The vendor shall submit certification letter from the manufacturer of submitted equipment certifying that the installer is an authorized and certified installer of the submitted equipment.
2. The vendor shall make all connections at all field devices and at the head-end; and shall make all necessary field adjustments for a fully functional system.

B. Shop Drawings: Signed and sealed by a qualified professional engineer or an RCDD.

1. Prior to assembling or installing the system, the Contractor shall provide complete shop drawings which include the following:
   a. List the name of the manufacturer's local representative and his/her phone number.
   b. Table of contents.
   c. Manufacturer's parts lists
   d. Product serial numbers
   e. Catalog cut sheets
   f. Installation instructions
   g. Equipment Details: Detail equipment assemblies and indicate dimensions, weights, required clearances, method of field assembly, components, and location of each field connection.
   h. Station-Arrangement Details
   i. Wiring Diagrams: Signal, and control wiring. Include the following:
      1) Single-line diagram showing interconnection of components.
      2) Cabling diagram showing cable routing.
   j. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved.
      1) Ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
   k. Manufacturer's warranty documents

2. All drawings shall be fully dimensioned.
3. Operating License: Submit evidence of application for FCC Radio Station Authorization prior to installing equipment when required for operation of the equipment.

C. As-Built Drawings

1. At the conclusion of the project, the Vendor shall provide "as built" drawings. The "as built" drawings shall be a continuation of the Contractors shop drawings as modified, augmented, and reviewed during the installation, check out and acceptance phases of the project. All drawings shall be fully dimensioned and prepared in DWG format using the latest version of AutoCAD.
2. The as-built drawings shall incorporate all updated system riser diagrams prepared in DWG format using the latest version of AutoCAD.

D. Manuals

1. At the conclusion of the project, the Vendor shall provide copies of the manuals as described herein. Each manual's contents shall be identified on the cover. The manual shall include names, addresses, and telephone numbers of each system integrator

installing equipment and systems and the nearest service representatives for each item of equipment for each system. The manuals shall have a table of contents and labeled sections. The manuals shall include all modifications made during installation, checkout, and acceptance. The manuals shall contain the following:

a. Hardware Manual
   1) The hardware manual shall describe all equipment furnished including:
   2) General description and specifications
   3) Installation and check out procedures
   4) Equipment layout and electrical schematics to the component level
   5) System layout drawings and schematics
   6) Alignment and calibration procedures
   7) Manufacturers repair parts list indicating sources of supply

b. Software Manual
   1) The software manual shall describe the functions of all software and shall include all other information necessary to enable proper loading, testing, and operation. The manual shall include:
   2) Definition of terms and functions
      a) Use of system and applications software
      b) Initialization, start up, and shut down
      c) Alarm reports
      d) Reports generation
      e) Data base format and data entry requirements
      f) Directory of all disk files

2. Operators Manual
   a. The operator’s manual shall fully explain all procedures and instructions for the operation of the system including:
      1) Computers and peripherals
      2) System start up and shut down procedures
      3) Use of system, command, and applications software
      4) Recovery and restart procedures
      5) Use of report generator and generation of reports
      6) Data entry
      7) Operator commands
      8) Alarm messages and reprinting formats
      9) System access requirements

3. Maintenance Manual
   a. The maintenance manual shall include descriptions of maintenance for all equipment including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective components.

1.6 QUALITY ASSURANCE

A. All items of equipment shall be designed by the manufacturer to function as a complete system and shall be accompanied by the manufacturer's complete service notes and drawings detailing all interconnections.

B. The contractor shall be an established communications and electronics contractor that maintains a locally run and operated business and has done so for at least 10 years. The contractor shall be a duly authorized distributor of the equipment supplied with full manufacturer's warranty privileges.

C. The contractor shall show satisfactory evidence, upon request, that he or she maintains a fully equipped service organization capable of furnishing adequate inspection and service to the system. The contractor shall maintain at his or her facility the necessary spare parts in the proper proportion as recommended by the manufacturer to maintain and service the equipment being supplied.

1.7 SINGLE SOURCE RESPONSIBILITY

A. Except where specifically noted otherwise, all equipment supplied shall be the standard product of a single manufacturer of known reputation and a minimum of 30 years of experience in the industry. The supplying contractor shall have attended the manufacturer's installation and service training classes. A certificate of this training shall be provided with the contractor's submittal.

1.8 SAFETY / COMPLIANCE TESTING

A. The communications system and its components shall, where applicable, bear the label of a Nationally Recognized Testing Laboratory (NRTL), such as Environmental Technology Laboratory (ETL), and shall be listed by their re-examination service. All work must be completed in strict accordance with all applicable electrical codes, under direction of a qualified and factory-approved contractor, and to the approval of the owner.

B. The PA system solution shall be consistent with those NEMA SB 40-2015 requirements that specifically apply to school paging and intercom systems only as outlined within the ANSI/NEMA SB 40-2015 standards publication.

1.9 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers

1. Rauland Telecenter U.
2. Bogen E700 IP.
3. Valcom.
4. Or approved equal.

2.2 PAGING ZONES

A. The paging zones shall be as follows:

1. Individual classrooms and offices with talk back (TB) speaker.
2. Each floor, sub-divided by each wing.
3. Gymnasium/Welness Center/Adaptive PE

4. Kitchen
5. Cafeteria
6. Media Center
7. Exterior Speakers
8. Parking Garage
9. Auditorium
10. All Call

2.3 BASIS OF DESIGN

A. The basis of design product shall be Rauland Telecenter U Public Address System.

2.4 PA SYSTEM EQUIPMENT AND MATERIAL

A. Server Software – Rauland Model TCC2000SW

1. Provides district wide paging, bell event scheduling, emergency notification and configuration for the entire district.
2. Provides the ability to configure the system and initiate system features per school and district wide from a web-based interface.
3. The software has the ability to sync system time to the Atomic Clock Signal or to the school's or district's network time server.
4. The software will provide a web-browser to deliver district wide emergency paging, pre-recorded messages, and tones from any authorized computer in the facility or the district. The software must be capable of automatically notifying district personnel via the WAN of an alarm condition.
5. The software can automatically broadcast emergency instructions via associated system hardware throughout an entire district when an alarm (e.g. lockdown, lockout, security, fire) is initiated via the web-based interface. The emergency instructions are preprogrammed and require no user intervention. The system provides redundant alarm annunciation over intercom/paging speakers and is not meant to replace primary fire alarm or security systems.
6. The software can be installed in cloud, virtual or physical server environments.
7. The web-based user interface supports secure HTTP browsing.
8. The server software supports encryption to ensure secure access.
9. The software shall support any combination of VoIP Telecenter U Campus Controllers for a minimum of 1000 facilities.
10. The software shall support a minimum of 50,000 IP Speaker Modules district wide.

B. VoIP Single Campus Controller – Rauland Model TCC2000

1. Provides call routing for paging and intercom for a single facility
2. Connects to the district provided Telephone Network via a SIP connection.
3. Supports a flexible numbering plan allowing two, three, four, five or six-digit extensions.
4. SIP interface to a district provided Telephone Network shall enable connected phones to display classroom call-ins, answer internal intercom call-ins, make pages, and change priorities of call-ins in progress.

5. Direct Dialing, two-way amplified voice intercom between any provided telephone or administrative console and IP speaker without the use of a press-to talk or talk-listen switch.
6. Ability to place two levels of call-in from any call-in switch.
7. The ability to answer intercom call-ins registered at administrative consoles and pre-selected telephones.
8. The ability to automatically escalate incoming call-ins to an alternate telephone or group of telephones if they remain unanswered for a predetermined amount of time.
9. The ability to manually upgrade an intercom call-in to an alternate telephone or group of telephones.
10. The ability for classrooms to “check-in” via push button when they have successfully secured their location during emergency.
11. Administrative console shall display locations that have not “checked-in” to confirm their secured location and provide hands-free audio monitoring and communication to unsecured locations.
12. The controller shall not need direct connection to any classroom via home run or distributed wiring. It shall communicate solely through the IP Network.
13. Single button access from any telephone on the system to distribute emergency announcements within the facility to all or select locations equipped with speakers. Emergency announcements originating from any assigned administrative telephone shall have priority over all regular system functions.
14. Ability for administrative consoles and connected phones to selectively monitor audio at any two-way speaker during an emergency.
15. Stores a minimum 48 hours of Bell Event Schedules, all emergency notification sequences as well as facility wide configuration.
16. System has the ability to sync system time to the Atomic Clock Signal or to the school’s or districts network time server.
17. System’s SIP Interface shall provide:
    a. Audio paging access from any telephone to any single intercom speaker, zone (group) of intercom/paging speakers or all speakers/paging horns throughout the entire facility.
    b. Ability to answer a call-in directed to that SIP extension.
    c. Ability to upgrade a call-in directed to that SIP extension
    d. Single button access from any telephone on the system to initiate alarm signals within the facility to all or select locations equipped with speakers.
    e. A minimum of 25 separate distinct alarm signals shall be provided. Alarm signals originating from any assigned administrative telephone shall have priority over all regular system functions.
    f. Ability to initiate school-wide emergencies including lockdown and evacuate sequences.
18. The system will have the ability to utilize a web-browser and a USB microphone connected to the PC to deliver district wide live emergency paging, pre-recorded messages, and tones from any authorized computer in the facility or district. The system must be capable of automatically notifying district personnel via the WAN of an alarm condition.

19. The system can automatically broadcast emergency instructions. Throughout an entire campus when an alarm (e.g. lockdown, lockout, security, fire) is tripped or manually activated. The emergency instructions are preprogrammed and require no user intervention. The system provides redundant alarm annunciation over intercom/paging speakers and is not meant to replace primary fire alarm or security systems

C. IP Addressable Modules:

1. The system shall provide multiple IP addressable modules for intercom, paging, and relay activation.
    a. All modules are POE 802.3af compliant.
    b. All Modules support DHCP.
    c. All Modules connect to the network with a single RJ-45 connector
2. IP Addressable Speaker Module – Rauland Model TCC2011
    a. Speaker modules shall interface classroom devices, such as speakers and call-in switches, to provide a reliable communications link to the administrative consoles and connected phones utilizing the school's data network. Capable of delivering a full 2 Watts of audio power to an 8 Ohm speaker, the speaker module provides excellent audio coverage for all K-12 classrooms. The speaker module can be easily programmed through the web browser's volume slider interface to adjust the audio power (0.25W, 0.5W, 1W, 1.5W and 2W) to each 8 Ohm speaker.
    b. Speaker modules shall be equipped with a SPST relay that can trigger a visual indicator, such as a strobe, whenever a high-priority audio signal is present.
    c. Speaker modules may belong to one or more of a minimum of 100 independent zones for zone paging, program/music distribution and class change tone reception; this assignment is a programmable function, changeable by time of day. Each IP Speaker Modules location shall be programmed in software to belong to any combination of software zones. IP Speaker Modules shall be designed to mount to ceiling and wall speakers specified herein and in the plenum space.
3. IP Addressable Zone Paging Module – Rauland Model TCC2022
    a. Zone paging modules convert the IP-based audio to an analog line-level audio signal to drive the Audio/Program Amplifiers specified herein.
    b. Zone paging modules shall connect multiple speakers for district all page, all page, zone paging, bells, audio events and, emergency notifications.
    c. Zone paging modules shall be rack mounted in the MDF/IDF's using the Rauland Model TCC2099 Universal Rack Mounting Kit.
    d. Zone paging modules shall be able to belong to one or more of 100 independent zones for live paging, bells, pre-recorded audio, and emergency
4. IP Addressable Auxiliary Input/output Module – Rauland Model TCC2033
    a. Auxiliary I/O Modules provide two (2) network enabled, individually addressable contact closures providing an interface to external systems such as fire alarm panels, security panels, strobes, and door latches.
    b. Auxiliary I/O modules provide the ability to connect a "Panic Button" to the system.
    c. Auxiliary I/O Modules shall be rack mounted using the Rauland Model TCC2099 Universal Rack Mounting Kit.

d. User can program relays to be activated manually, through an event/bell schedule and during emergency notification notifications.

5. IP Addressable Program Line Input Module – Rauland Model TCC2055

a. Line Input Module converts stereo or mono line-level analog audio to IP-Based Data for use in the Telecenter U system.

b. Equipped with 3.5mm (headphone style) input socket.

c. Desktop or rack mountable with Rauland Model TCC2099 Universal Rack Mounting Kit.

d. Includes a male 3.5mm to dual male RCA connector cable.

6. Twenty-Four (24) Port Gateway – Rauland Model TCC2024

a. Supports 24 classrooms that utilize 25 Volt speakers and all current Tele-center call switches for front office notification

b. Intercom, zone paging, emergency notification, program/music and event tone distribution.

c. Compatible with CAT5e, CAT6, CAT6A and 2-pair shielded, twisted field cabling.

d. Built-in paging audio amplification of 25 Watts total per Gateway (5 Watts maximum per port).

e. Requires 10/100/1000 Mb, multicast-enabled switch on fully switched network.

f. 10/100/1000 RJ45 network socket connector on front panel.

g. Two (2) female Amphenol-style connectors for field wiring on back of unit.

h. Up to twenty (20) TCC2024 Gateways per Telecenter U school.

i. Dimensions: 1.7”H x 19.0” W x 15.25” D.

j. Power requirements: 90-260VAC, 1 Amp.

k. Manufacturers 5-year warranty.

D. IP Addressable Administrative Console – Rauland Model TCC2044

1. A full color screen with 64 soft keys, 3 lines select, volume control, push to talk, speakerphone mode, left/right and up/down scrolling.

2. Audio paging access from any Console to any single intercom speaker, zone (group) of intercom/paging speakers or all speakers/paging horns throughout the entire school.

3. Programmable soft key access from any console on the system to initiate alarm signals within the school to all or select locations equipped with speakers. A minimum of 25 separate distinct alarm signals shall be provided. Alarm signals originating from any assigned administrative telephone shall have priority over all regular system functions.

4. Programmable soft key access from any console to automatically broadcast page emergency instructions throughout an entire school when an alarm (e.g. lockdown, lockout, security, fire) is tripped or manually activated. The emergency instructions are preprogrammed and require no user intervention. The system provides redundant alarm annunciation over intercom/paging speakers and is not meant to replace primary fire alarm or security systems.

5. Ability to perform intercom communication to any single IP Addressable Speaker Module.

6. Ability to display 3 call-ins at a time on the screen, with unlimited number of call-ins annunciating and the ability to scroll to view all call-ins.

7. Ability to upgrade a call-in via a soft key.

8. Programmable soft key access from any console for activating relays, campus wide.

9. Ability to maintain, along with controller and other IP Modules system functions, including intercom, bells, and paging for the local campus in the event of district wide connection loss

E. Audio Paging/Program Amplifier(s)

1. Power amplifier(s) shall be provided to provide a minimum of 2 watts of power to all paging speakers and 15 watts of power to all paging horns.

2. The maximum load on the paging/program amplifiers shall be 80% of the rated maximum output of the amplifiers.

3. Provide Rauland DAX-Series, JBL CSA-Series, Stewart Audio CVA25- 1 Series and/or Biamp Series MPA to meet the above requirements

F. Universal Control Panel - Check-in/Emergency Dual Pushbutton Call-in Switch –Model SWC LT200SP Serial Ports (RS-232) - Speed: 2400-115,200 bps (Ports 1,2,3) 2400-57,600 bps (Port 4)- Pins: TX, RX and GND Connector type: Screw terminal. IR Ports- Connector type: Screw terminal - I/O Ports (FLEX-LT200, -LT300 and T6) - Output: open collector, current limited to 100mA, (24VDC max) Compliance and supported features: Compliant with IEEE 802.3/802.3u (100BASE-TX) Compliant with ISO 802-3 / IEEE 802.3 (10BASE-T) Supports auto-negotiation. Supports automatic polarity detection and correction Supports HP Auto MDI/MDI-X

1. One (1) “Check-in” call-in switch that shall activate a distinctive “NORMAL” call annunciation from single button activation under emergency conditions and shall activate a “Check-in” annunciation to confirm the location is secured during lockdown conditions. The button shall be blue in color and shall be clearly marked “CHECK IN” and will route the call-into any one or more Administrative Telephones and/or Displays for quick and easy response from an Administrative Telephone.

2. One (1) “Emergency” call-in switch that shall activate a distinctive “EMERGENCY” level call from single button activation. The button shall be red in color and shall be clearly marked “EMER” and will route the call-in to any one or more Administrative Telephones for quick and easy response. Provide as indicated on the drawings.

G. Tile Ceiling Mounted Intercom Speaker – Rauland Model BAFKIT2X2L8RJ

1. Shall be a pre-assembled 2 foot by 2 foot lay-in speaker, baffle and back box assembly consisting of a premium 8 Ohm, 8” speaker, a perforated steel baffle with white baked epoxy finish and an integrated back box that covers the full area of the baffle.

2. The speaker assembly shall include a female RJ-45 modular socket and mounting bracket to facilitate connection to the TCC2011 IP Speaker Module specified herein. Provide as indicated on drawings.

H. Gypsum Ceiling Mounted Intercom Speaker Assembly – Rauland Model ACC1480

1. Shall consist of a premium 8 Ohm, 8” loudspeaker mounted on a 12-7/8” round white epoxy steel baffle. The recessed ceiling back box shall be an 8” round enclosure with a plaster flange mounting ring and a depth of 4-1/8” (Rauland Model ACC1110).

2. The speaker assembly shall include a female RJ-45 modular socket and mounting bracket to facilitate connection to the TCC2011 IP Speaker Module specified herein.

I. Recessed Wall Mounted Intercom Speaker Assembly – Rauland Model ACC1480

1. Shall consist of a premium 8 Ohm, 8" loudspeaker mounted on a 12-7/8" round white epoxy steel baffle. The recessed wall back box shall be an 8.75" square enclosure with a depth of 4" (Rauland model ACC1100).

2. The speaker assembly shall include a female RJ-45 modular socket and mounting bracket to facilitate connection to the TCC2011 IP Speaker Module specified herein. Provide as indicated on drawings.

J. Surface Mounted Intercom Speaker Assembly – Rauland Model ACC1480

1. Shall consist of a premium 8 Ohm, 8" loudspeaker mounted on a 12-7/8" round white epoxy steel baffle. The back box shall be fabricated drawn aluminum and finished in a polished brushed aluminum with a clear lacquer finish. It shall measure 10.75" diameter with a 3.468" projection (Lowell Model LCS-8NS).

2. The speaker assembly shall include a female RJ-45 modular socket and mounting bracket to facilitate connection to the TCC2011 IP Speaker Module specified herein. Provide as indicated on drawings.

K. Tile Ceiling Mounted Paging Speaker – Rauland Model BAFKIT2X2L70V

1. Shall be a pre-assembled 2 foot by 2 foot lay-in assembly complete with 8" full range speaker, 70Volt line matching, rotary-select tap transformer, perforated steel baffle with white baked epoxy finish and an integrated back box that covers the full area of the baffle.

2. The speaker assembly shall have a pair of speaker wires through a hole suitable for a ¾ "conduit fitting as the connection point for twisted/shielded cabling to the Audio Paging/Program Amplifiers specified herein. Provide as indicated on the drawings.

L. Tile Ceiling Mounted Paging Speaker with Volume Control – Rauland Model BAFKIT2X2LVC

1. Shall be a pre-assembled 2 foot by 2 foot lay-in assembly complete with 8" full range speaker, 25/70Volt line matching transformer, perforated steel baffle with white baked epoxy finish and an integrated back box that covers the full area of the baffle.

2. The speaker assembly shall have a pair of speaker wires through a hole suitable for a ¾ "conduit fitting as the connection point for twisted/shielded cabling to the Audio Paging/Program Amplifiers specified herein.

3. The front panel accessible volume control permits the end user to adjust the loudness of the speaker to a comfortable level. Provide as indicated on the drawings.

M. Gypsum Ceiling Mounted Paging Speaker Assembly – Rauland Model ACC1400

1. Shall consist of a high efficiency loudspeaker (Rauland Model US0188) complete with a 25/70 Volt multi-tap line matching transformer mounted on a round white epoxy steel baffle (Rauland Model ACC1000). The recessed ceiling back box shall be an 8" round enclosure with a plaster flange mounting ring and a depth of 4-1/8" (Rauland Model ACC1110). Provide as indicated on the drawings.

N. Recessed Wall Mounted Paging Speaker – Rauland Model US0188

1. Shall be an 8" permanent magnet seamless cone type with an additional cone provided to extend high frequency response. It shall have a frequency range of 65-17,000Hz, an 8-watt program power-handling capacity and an axial sensitivity of 93db at 1 watt with a 1-watt input. Voice coil shall be ¾" diameter with an impedance of 8 Ohms. The speaker shall be equipped with a multi-tap transformer (0.312, 0.625, 1.25, 2.5 and 5 watts) at 25V and 70V.

2. The recessed back box shall be of heavy gauge cold-rolled steel, spot welded for stability with a rust-retardant gray primer finish. Acoustically treat the interior to eliminate mechanical resonance. The back box shall be 10-3/4" square by 3.75" deep (Rauland Model ACC1105). 3. The baffle shall be constructed of 22-gauge cold-rolled steel that is zinc-treated to resist corrosion. The finish is baked, powdered white epoxy which is virtually scratch- and mar-proof. (Rauland Model ACC1003). Provide as indicated on the drawings.

O. Surface Ceiling Mounted Paging Speaker – Rauland Model US0188

1. Shall be an 8" permanent magnet seamless cone type with an additional cone provided to extend high frequency response. It shall have a frequency range of 65-17,000Hz, an 8watt program power-handling capacity and an axial sensitivity of 93db at 1 watt with a watt input. Voice coil shall be ¾" diameter with an impedance of 8 Ohms. The speaker shall be equipped with a multi-tap transformer (0.312, 0.625, 1.25, 2.5 and 5 watts) at 25V and 70V.
2. The surface back box shall be 18-gauge cold-rolled steel with an attractive white epoxy finish. The interior surfaces are jute-lined to prevent metallic resonance, vibration and provide proper acoustical results. The back box shall be 12-1/2" square by 4" deep (Rauland Model ACC1112).
3. The baffle shall be constructed of 22-gauge cold-rolled steel that is zinc- treated to resist corrosion. The finish is baked, powdered white epoxy which is virtually scratch- and mar-proof. (Rauland Model ACC1003). Provide as indicated on the drawings.

P. Large Space Surface Ceiling Mounted Paging Speakers (Gymnasium, Wellness, Adaptive PE, etc.)

1. The Industrial/Institutional surface mount speaker system shall consist of a round enclosure and base unit with integral compression driver horn speaker for voice communications. Enclosure and base shall be 18-gauge steel spin-formed and protected overall by a baked on powder coat urethane finish. The base shall have provisions for attachment to a common 4" recessed outlet box or to be fastened directly to a wall by screws as large as 1/4". Wiring shall enter through back for hidden cable or via one of four side entry K.O.s for surface cable or 1/2" conduit. The enclosure shall attach to the base with (4] #10 stainless steel hex drive screws. Color shall be UV stable White with a textured finish.
2. Frequency response shall be 500 to 7000 Hz. on axis. SPL at 16-watt input at 1 meter shall be 117 dB. Power handling capability shall be 16 watts continuous duty.
3. The speaker system in compliance with this specification is Fourjay Model I5445 (45-ohm impedance) or Fourjay Model IS4T16 (25- or 70-volt audio line].

Q. Recessed Wall Mounted Exterior Paging Speaker Assembly

1. The tamper and vandal-proof speaker assembly consisting of grille, housing, and driver shall be Fourjay's Model 416-TF. The grille shall be 16-gauge stainless steel. 10"x10". and attach to the housing with four 8x1" stainless steel spanner head screws. The housing shall be 18-gauge, enameled steel. 8"x8"x6". with five combination 1/2" - 3/4" conduit knockouts. The 25/70-volt line driver shall have a 1-1/2" voice coil with a frequency response of 500 to 7000 Hz and handle 16 watts RMS.

R. Pendant Mount Speaker

1. 3-hook, enclosed ABS design
2. 70/25V selectable transformer
3. Press terminals for wiring

4. Built-in safety loop for additional mounting security
5. Includes 11.25" hanging apparatus
6. Specifications
   a. RMS Power: 30W
   b. Max. Power: 60W
   c. Transformer Type: 70/25V (selectable)
   d. Transformer Power Type: 30W, 15W, 7.5W.5W, 2.5W, 1W, 0.5W, 0.25W & 8 Ohms
   e. Termination Type: Press terminal
   f. Sensitivity (1W/1M): 92dB
   g. Maximum SPL (Pax/1 M): 93.4dB
   h. Driver Impedance: 8 Ohms
   i. Magnet: 11 oz. ferrite
   j. Frequency Response Range: 90Hz ~ 20kHz
   k. Dispersion® 1000Hz: 100° Conical
   l. Driver: 5" polypropylene woofer, 0.5" mylar tweeter

7. Basis of Design: Speco Technologies SP30PTx.

S. Exterior Speaker, Pole Mounted

1. IP PoE One-Way Horn

   a. Basis of design: Valcom VE130AL. The VE130AL is a self-contained, paging system which enables voice paging over an IP network. The VE130AL consists of a high efficiency horn and a Network Interface allowing stand-alone capability when used with a SIP telephone system or can be accessed from a variety of Valcom managed VoIP products.

   b. RJ-45 network connection

   c. Network Activity LEDs

   d. Power over Ethernet (PoE) 802.3af compatible.

2. Components for Exterior Pole Mounted Speaker:

   a. Furnish and install (1) heater and thermostat, (1) media converter, (1) 95W POE injector, and (1) surge protector in NEMA 4x rated heated enclosure sized to accommodate all components at each speaker.

   b. Furnish and install 1.5kVA, 277V to 120V stepdown transformer and double duplex receptacle in a NEMA 4x enclosures at each speaker.

   c. Furnish and install rack mounted media converter in the corresponding telecommunications room.

   d. Basis of Design

      1) Media Converter: Altronix NETWAY4EWPX

      2) Heater: Hoffman DAH301

      3) Temperature Control Switch: Hoffman ATEMNC

      4) POE Injector: Bosch NDP-600A1

      5) Surge Protector: Ditek DTK-MRJPOE

      6) Nema 4X Enclosure: Hoffman ELC404020 Enclosure (or larger to accommodate all components), EP4040AL Backplate and CPMK16 Pole Mount

7) Tamper Switch: interlogix 3025T-M

8) Transformer: Hammond Power 1.5kVA, 277V to 120V

T. Bus Loading Paging Station

1. Provide at a location to facilitate the release of students. The station shall consist of a flush or surface mounted locking enclosure (Lowell Models BLS-1 or BLS-1S), a single line telephone and a SIP to Analog Gateway. Provide as shown on the drawings.

U. Remote Audio Input Jack Plate

1. Provide a single gang plate in the office area to facilitate the connection of a headphone level audio source for broadcast of program material through the system (ProCo Model Type A). The jack plate shall have a single 3.5mm female stereo input. The jack plate shall be engraved “INTERCOM PROG. INPUT”

2.5 POE ANALOG CLOCKS

A. Approved Manufacturers

1. Primex
2. Sapling
3. American Time
4. Or approved equal

B. System Description

1. System devices shall be managed and monitored from the Manufacturer cloud-based system software, that allows OWNER to remotely manage system device settings and monitor system devices.
2. System shall consist of system clocks enabled with IP Ethernet/PoE technology.
3. System shall provide synchronized time by way of system devices connected to OWNER'S IP Ethernet/PoE network.
4. System shall not require the installation of any onsite system hardware or software, with the exception of the specified system devices.
5. Clocks shall be capable of automatically adjusting for Daylight Saving Time.
6. Clocks shall be fully portable, capable of being relocated at any time.
7. Clocks shall receive UTC time from a Network Time Protocol (NTP) time source; allow up to three NTP time sources for failover purposes.
8. Clocks shall operate with a free-running accuracy of .45 seconds per day, and will continue to operate in the absence of receiving the UTC time from an NTP time source.
9. Analog clocks shall report gross mechanical failures by way of automatically performing a daily midnight hand verification check; which if this check shall fail for three consecutive days, the clock shall report a hand position failure status, resulting in a clock warning state within the system software.

C. System software specifications

1. System software shall provide an online device configuration procedure that allows OWNER supplied settings to be installed on system IP network devices prior to shipment from the Manufacturer.
2. System devices shall download settings from the system software over the OWNER'S existing IP network.

3. System shall provide a mobile app that allows the OWNER to add system devices to the system software or edit the devices' assigned network and other primary settings for those devices added to the system software.
4. System software shall log the NTP accuracy of the system devices.
5. System software shall monitor and display the operating status of system devices.
6. System software shall provide an automated reporting method to notify system users of device operating statuses that may warrant corrective action.
7. System software shall allow the OWNER to manage authorized system users, including user access to data and system settings that is based on the role assigned to each system user. Access can be limited to viewing and managing the system, including reports, device settings, system users, and account settings.
8. System software shall maintain and store data for up to a minimum of ten (10) years.

D. Encryption and Authentication specifications

1. User software access sessions between the web browser and the system software shall be encrypted by the Hypertext Transfer Protocol Secure (HTTPS) protocol.

E. System Administration specifications

1. Software interface shall allow the OWNER'S system admin user(s) to manage the system components, including system device settings, reports, system-wide user password complexity settings and user session timeout setting to align with OWNER information security policies and procedures, manage system users and grant users' access to system data and features, activate and deactivate system users, and view users' login history.
2. System software shall allow each system user to manage their own system profile, including their password and contact settings.
3. System software shall allow system device settings to be user-defined to meet OWNER requirements.
4. System software shall allow devices, that send data to and download data from the system software over an IP network, to be assigned to a DHCP or Non-DHCP primary and an alternate network for failover purposes. Network settings are managed within the system software, allowing remote management to migrate devices from one network to another.
5. System software shall allow user-defined reporting; the system shall store and present historical data in the form of reports. User-defined data shall include the system devices included in a report, the frequency a report is system generated, and a specific range of data included in a report. System reports shall be displayed in the system software electronically within the interface to allow system users to download reports. The system shall allow report data to be restricted based on the role(s) assigned to the system users.

F. System devices with IP Ethernet/PoE network communication specifications

1. Network Communication Protocols: Hypertext Transfer Protocol Secure (HTTPS) | IP Addressing: Dynamic Host Configuration Protocol (DHCP and static IP addressing | Data Packet Size: typically less than 5 kilobytes (kB)
2. Network setting data is stored locally in devices shall be encrypted and access to locally stored setting data can be controlled by a system admin user.
3. Manufacturer shall provide standalone configuration software to locally configure a device to meet OWNER security policies if IP network setting data cannot be stored in third-party software or to troubleshoot device network connectivity issues.

G. System Software

1. Basis of Design System Software: Primex OneVue
2. Cloud-based software that resides on Amazon Web Services (AWS) and is accessed via the internet.
3. System software stores and monitors system device operating conditions.
4. All system devices and system settings are managed from the system software.

H. Analog Clocks shall meet the following specifications

1. Clocks (single-sided) shall be wall-mounted.
2. Additional colors, finishes, and dial faces are available from Manufacturer.
3. Clock faces can be customized by Manufacturer to display the organization name or logo as specified.
4. Clock frames and lenses are of durable thermoplastic.
5. Clocks shall have a tamper-proof/theft resistant clock-lock mounting slots.
6. A dual-mount kit is available from the Manufacturer that combines two single clocks to create a dual-sided clock.
7. If power is interrupted, the clock will stop until power resumes. Upon resumption of power, the clock will self-correct to the current time.
8. Battery-operated analog clocks shall have a 5-year nominal battery life.
9. Installer will furnish clock batteries in accordance with Manufacturer instructions.
10. Shall have a USB port that can be used to supply power via external supply and allow the clock to operate using a conventional Ethernet connection without PoE.

I. Analog Clocks

1. Education series
2. Size: 12.5"] and 16"
3. Color: Black

J. Wire Clock Guard

1. (Part No. 14123) Analog Wire Guard, 18” (45.72cm) square

2.6 OBSERVATION ROOM INTERCOM

A. The observation intercom shall be a standalone IP intercom system as shown on the drawings.

B. The system shall consist of a PoE ceiling speaker/microphone located in rooms being observed; and two button PoE intercom wall stations located in observation rooms. Each room being observed shall have an associated intercom station and a POE speaker in the room being observed.

C. The intercom wall station and the ceiling speaker shall be patched through the PoE security network data switch provided by the Owner. The speaker and the intercom station shall be linked via web based software.

D. Ceiling Speaker/Microphone

1. The Wahsega Labs WL-SPKR-22-INF-1 is a drop-in 2x2 ceiling tile speaker which supports dual registration with InformaCast® and SIP, powered via Power-over-Ethernet (PoE).

E. Intercom Wall Station

1. The Wahsega Labs WL-IC-FLMT-INF-I-W 2-button stations are network-based wall intercom stations used to establish communication between specific areas of a facility.

2. The stations feature a Push to Call, Push to Talk, and a Cancel. The stations shall be configured to listen into the classroom; conversations in the Observation room shall not be audible in the classroom unless the Push to Call button is pressed.

F. Wiring

1. Wiring to the ceiling speaker and the intercom wall station shall be a Category 6A data drop to each. The cables shall be terminated per the manufacturer's instruction at the speaker and the wall station. In the telecommunications room the cables shall be terminated in a patch panel.

2.7 UNINTERRUPTIBLE POWER SUPPLY (UPS)

A. Install a rack mounted uninterruptible power supply capable of sustaining normal operation of complete telecommunications system for a minimum of one hour in event of a commercial power failure. Power supply shall conform to telecommunications manufacturer requirements. The UPS unit shall also provide conditioning of the source power to maintain both frequency and voltage levels. The UPS shall also be Simplified Network Management Protocol (SNMP) addressable and manageable through a standard Ethernet port. The Vendor shall furnish and install the wiring connection from the UPS/PDU Ethernet Port to an available Ethernet Switch Port, as well as configure the UPS/PDU with the appropriate, Owner-provided IP address.

B. UPS Basis of Design: Eaton 5PX UPS, 5PX3000RTN

C. PDU Basis of Design: Eaton Metered Outlet Rack PDU, 1U, EMIT03-10.

2.8 CONDUCTORS AND CABLES

A. Conductors: Jacketed, twisted pair and twisted multipair, untinned solid copper (West Penn # AQC 439 or equal). Sizes as recommended by system manufacturer, but not smaller than No. 22 AWG. – Us when cabling a 25/70V speaker.

B. Insulation: Thermoplastic, not less than 1/32 inch thick.

C. Shielding: For speaker-microphone leads and elsewhere where recommended by manufacturer; No. 34 AWG tinned, soft-copper strands formed into a braid or equivalent foil.

1. Minimum Shielding Coverage on Conductors: 60 percent.

D. Plenum Cable: Listed and labeled for plenum use.

E. Category 5E UTP – Use when connecting an IP device.

F. Provide all necessary hardware and software for a complete and operable system.

2.9 WIRING

A. Category 6A copper (IP Speaker Homerun/ Console and NTP Sync.).

B. West Penn #25292B or approved equal (70V Paging Circuits).

C. 1-foot Category 6A patch cable from the IP Addressable Speaker Module to the Intercom Speaker.

D. 35-foot Category 6A patch cable from the IP Addressable Speaker Module to the Call-in Station.

E. Patch cables to interconnect IP Addressable Zone Paging, Auxiliary.

F. Input/output and Program Line Input Modules to the network at the head end.

G. All cabling and patch cables shall be plenum-rated.

2.10 INTEGRATION WITH PHONE SYSTEM

A. All equipment shall be installed and connected in strict accordance with the manufacturer's recommended instructions.

B. Provide integration with Owner's telephone system so that system wide paging is feasible using any telephone handset.

2.11 INTEGRATION WITH IN-CEILING INSTRUCTIONAL AUDIO SYSTEM

A. Furnish and install two-conductor cable from the public address (PA) system speaker to the Topcat speaker for PA override. Coordinate requirements with the in-ceiling instructional audio system vendor.

B. A teacher can use their Lightspeed Flexmike microphone to send an alert through the building's public address system. A Contact Closure on the Lightspeed Topcat system is a normally open relay that can be closed by pressing the up and down volume buttons at the same time for 3 seconds on the Flexmike. This activates the contact closure function on the Topcat, which external systems use to perform a prescribed action, such as notifying the appropriate parties of a classroom alert.

2.12 Furnish and install Category 6A cable from the Topcat speaker to the public address (PA) system emergency call station input. Coordinate requirements with the in-ceiling instructional audio system vendor.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine conditions, with the installer present, for compliance with requirements and other conditions affecting the performance of the Nyquist E7000 Series Educational System.

B. Do not proceed until unsatisfactory conditions have been corrected.

3.2 EQUIPMENT MANUFACTURER'S REPRESENTATIVE

A. All work described herein to be done by the manufacturer's authorized representative shall be provided by a documented factory authorized representative of the basic line of equipment to be utilized.

B. The manufacturer's representative shall provide a letter with submittals from the manufacturer of all major equipment stating that the manufacturer's representative is an authorized distributor. This letter shall also state that the manufacturer guarantees service performance for the life of

the equipment and that there will always be an authorized distributor assigned to service the area in which the system has been installed.

C. The contractor shall furnish a letter from the manufacturer of the equipment. This letter shall certify that the equipment has been installed according to factory intended practices, that all the components used in the system are compatible, and that all new portions of the systems are operating satisfactorily. Further, the contractor shall furnish a written unconditional guarantee, guaranteeing all parts and all labor for a period of five years after final acceptance of the project by the owner.

3.3 INSTALLATION

A. The installation, adjustment, testing, and final connection of all conduit, wiring, boxes, cabinets, etc., shall conform to local electrical requirements and shall be sized and installed in accordance with the manufacturer's approved shop drawings.

B. Low-voltage wiring may be run exposed above ceiling areas where they are easily accessible.

C. The contractor shall install the new system at the location shown on the plans.

D. All Staff Stations and Call Switches shall be wall-mounted:

1. Mount at 54" AFF.
2. All wiring should be concealed.
3. Verify exact location with architect.
4. Avoid mounting near doors to prevent students from activating and running out of the rooms.

E. Admin Stations can be desk or wall mounted.

F. Speaker and telephone lines run above ceiling and not in conduit shall be tie-wrapped to a ceiling joist with a maximum spacing of 8' between supports. No wires shall be laid on top of ceiling tile.

G. Connect field cable to each Analog Speaker transformer using UL butt splices for #22 AWG wire.

H. Contractor shall provide a minimum of eight hours of configuration and operational instruction to school personnel.

I. On the first school day following installation of the Nyquist System, the contractor shall provide a technician to stand by and assist in system operation.

J. Mark and label all demarks IDF and MDF points with destination point numbers. Rooms with more than one outlet shall be marked XXX-1, XXX-2, XXX-3, etc. where XXX is the room number.

K. No graphic room number shall exceed the sequence from 000001 through 899999.

1. All outside speakers shall be on a separate Page Zone and Time Zone.
2. All zones shall be laid out not to exceed 30 Watts (@25V) maximum per zone.
3. All hallway speakers shall be tapped at 1 Watt (@25V) maximum.
4. All outside horns shall be tapped at 3.75 Watts (@25V) maximum.

5. All classroom speakers shall be tapped at ½ Watt (@25V) maximum.
6. Large rooms, such as cafeterias, gymnasiums, auditoriums, etc, shall be tapped at 2 Watts (@25V) maximum.

L. Plug disconnect: All major equipment components shall be fully pluggable by means of multi-pin receptacles and matching plugs to provide for ease of maintenance and service.

M. Protection of cables: Cables within terminal cabinets, equipment racks, etc., shall be grouped and bundled (harnessed) as to type and laced with No. 12 cord waxed linen lacing twine or T and B wire-ties, or hook and loop cable management. Edge protection material shall be installed on edges of holes, lips of ducts, or any other point where cables or harnesses cross a metallic edge.

N. Cable identification: Cable conductors shall be color-coded, and individual cables shall be individually identified. Each cable identification shall have a unique number located approximately 1-1/2" from cable connection at both ends of cable. Numbers shall be approximately 1/4" in height. These unique numbers shall appear on the As-Built Drawings.

O. Shielding: Cable shielding shall be capable of being connected to common ground at point of lowest audio level and shall be free from ground at any other point. Cable shields shall be terminated in the same manner as conductors.

P. Provide complete “in service" instructions of system operation to school personnel. Assist in programming of telephone system.

3.4 GROUNDING

A. The contractor shall provide equipment grounding connections for Integrated Telecommunications/Time/Audio/Media System as indicated. Tighten connections to comply with tightening torques specified in UL Standard 486A to ensure permanent and effective grounds.

B. The contractor shall provide ground equipment, conductor, and cable shields to eliminate shock hazard and to minimize the greatest extent possible, ground loops, common mode returns, noise pickup, cross talk, and other impairments.

C. The contractor shall provide all necessary transient protection on the AC power feed and on all station lines leaving or entering the building.

D. The contractor shall note on their drawings the type and locations of these protection devices and all wiring information.

E. The contractor shall furnish and install a dedicated, isolated earth ground from the central equipment rack and bond to the incoming electrical service ground buss bar.

3.5 PROTECTION

A. The contractor shall provide all necessary transient protection on the AC power feed and on all station lines leaving or entering the building.

B. The contractor shall note on their system drawings, the type and location of these protection devices and all wiring information. Such devices are not to be installed above the ceiling.

3.6 SERVICE AND MAINTENANCE

A. The contractor shall, at the owner's request, make available a service contract offering continuing factory authorized service of this system after the initial hardware and software warranty periods.

B. System shall include software maintenance that includes bug fixes and new feature releases for a period of five years. In addition, the contractor shall provide at the owner's request additional maintenance contracts that are available as one-year, three-year, and five-year extensions. The contractor shall provide a 24-hour response time from call by customer.

C. The system manufacturer shall maintain engineering and service departments capable of rendering advice regarding installation and final adjustment of the system.

3.7 DOCUMENTATION

A. Provide the following directly to the Owner.

1. One printed copy of all field programming for all components in system
2. One copy of all diagnostic software with a copy of field programming data for each unit
3. One copy of all field wiring runs, location, and end designation of system

3.8 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup check according to the approved manufacturer's written instructions.

3.9 TRAINING AND SERVICE

A. Comply with Section 26 00 00.

B. Conduct four 4-hour training sessions. Train the Owner's maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

C. Conduct four 4-hour training sessions. Train teachers and administration personnel on system operation.

3.10 SPARE PARTS

A. Furnish the following component at the end of the project to the Owner:

1. Classroom Talkback IP speaker: 10
2. Paging speaker: 10
3. Surface Speaker: 5
4. Exterior speaker: 5
5. Pendant Speaker: 2
6. Check-in/Emergency Call Station: 20

End of Section

Section 27 51 29

DIGITAL SIGNAGE AND CLOCK SYSTEM

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. Furnish and install a complete Digital Signage and Clock System as described herein.

1.4 DEFINITIONS

A. A user-configurable messaging display and software platform that integrates with and supports emergency systems to deploy visual and audio alerts, synchronized content, messaging, audible tones, and clock images for:

1. Emergency notification/communication.
2. Routine digital signage and messaging.
3. Clock display.

B. Ethernet: A system to form a local area network with protocols to control the passing of information and provide time synchronization via SNTP (Simple Network Time Protocol).

C. Local Area Network (LAN): connects computers and devices in a limited geographical area.

D. Wi-Fi: A wireless networking technology that allows computers and other devices to communicate over a wireless signal. It describes network components that are based on one of the 802.11 standards developed by the IEEE and adopted by the Wi-Fi alliance.

E. Software Service Agreement (SSA): a software licensing and distribution model.

1. Software is licensed on a subscription basis for terms of one, two and three years.
2. It is centrally hosted and accessed by users over the Internet.

1.5 PROGRAMMING

A. Coordinate and obtain a written approval of system functionality from the Owner prior to programming.

B. Perform a walk-through with the Owner and demonstrate the system functionality.

C. Make any adjustments to system functionality after initial programming if necessary to achieve the desired functionality requested by the Owner. Coordinate all required reprogramming with the Owner as required as part of this contract.

D. Obtain a written final letter of acceptance from the Owner upon completion of system functionality programming and demonstration.

1.6 SUBMITTALS

A. Comply with requirements specified in Division 01 and the following:

1. The vendor shall submit certification letter from the manufacturer of submitted equipment certifying that the installer is an authorized and certified installer of the submitted equipment.
2. The vendor shall make all connections at all field devices and at the head-end; and shall make all necessary field adjustments for a fully functional system.

B. Shop Drawings

1. Prior to assembling or installing the system, the Contractor shall provide complete shop drawings which include the following:
   a. List the name of the manufacturer’s local representative and his/her phone number.
   b. Table of contents.
   c. Manufacturer’s parts lists
   d. Product serial numbers
   e. Catalog cut sheets
   f. Installation instructions
   g. Typical wiring diagrams
   h. Drawings showing equipment locations
   i. Manufacturer’s warranty documents

2. All drawings shall be fully dimensioned.
3. Operating License: Submit evidence of application for FCC Radio Station Authorization prior to installing equipment when required for operation of the equipment.

C. As-Built Drawings

1. At the conclusion of the project, the Vendor shall provide “as built” drawings. The “as built” drawings shall be a continuation of the Contractors shop drawings as modified, augmented, and reviewed during the installation, check out and acceptance phases of the project. All drawings shall be fully dimensioned and prepared in DWG format using the latest version of AutoCAD.
2. The as-built drawings shall incorporate all updated system riser diagrams prepared in DWG format using the latest version of AutoCAD.

D. Manuals

1. At the conclusion of the project, the Vendor shall provide copies of the manuals as described herein. Each manual's contents shall be identified on the cover. The manual shall include names, addresses, and telephone numbers of each system integrator installing equipment and systems and the nearest service representatives for each item of equipment for each system. The manuals shall have a table of contents and labeled sections. The manuals shall include all modifications made during installation, checkout, and acceptance. The manuals shall contain the following:
   a. Hardware Manual
      1) The hardware manual shall describe all equipment furnished including:
      2) General description and specifications
      3) Installation and check out procedures
      4) Equipment layout and electrical schematics to the component level
      5) System layout drawings and schematics
      6) Alignment and calibration procedures
      7) Manufacturers repair parts list indicating sources of supply
   b. Software Manual
      1) The software manual shall describe the functions of all software and shall include all other information necessary to enable proper loading, testing, and operation. The manual shall include:
      2) Definition of terms and functions
         a) Use of system and applications software
         b) Initialization, start up, and shut down
         c) Alarm reports
         d) Reports generation
         e) Data base format and data entry requirements
         f) Directory of all disk files

2. Operators Manual
   a. The operator's manual shall fully explain all procedures and instructions for the operation of the system including:
      1) Computers and peripherals
      2) System start up and shut down procedures
      3) Use of system, command, and applications software
      4) Recovery and restart procedures
      5) Use of report generator and generation of reports
      6) Data entry
      7) Operator commands
      8) Alarm messages and reprinting formats
      9) System access requirements

3. Maintenance Manual
   a. The maintenance manual shall include descriptions of maintenance for all equipment including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective components.

1.7 QUALITY ASSURANCE

A. Manufacturer must provide documentation of at least 10 continuous years of experience supplying networked systems in the education market.

B. Installer must be experienced in the installation of networked systems.

1.8 REGULATORY REQUIREMENTS

A. Equipment and components furnished shall be of manufacturer's latest model.

B. Refurbished equipment, upgraded to as-new condition, may be offered for product evaluation purposes and sold as such at discounted pricing.

C. System shall be installed in compliance with local and state authorities having jurisdiction.

1.9 DELIVERY, STORAGE AND HANDLING

A. Deliver all components to the site in the manufacturer's original packaging.

B. Packaging shall contain manufacturer's name and address, product identification number, and other related information.

C. Store equipment in finished building, unopened containers until ready for installation.

1.10 FIELD CONDITIONS

A. Displays shall not be installed until painting and other finish work in each room is complete.

B. Coordinate installation of 110 VAC outlets to all locations where a display shall be installed unless a suitable 110 VAC legacy power source already exists.

C. The display shall be installed within 4 feet of a 110 VAC outlet or within 12 inches of a legacy 110 VAC power source having a molex connector.

1.11 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers

1. American Time, EverAlert Emergency Communication Platform
2. Visix
3. RiseVision
4. Or approved equal.

2.2 BASIS OF DESIGN

A. The basis of design product shall be EverAlert™ by American Time.

2.3 SYSTEM FEATURE DESCRIPTION

A. Displays shall include the following features:

1. Smart 22” class HD screen with built-in speakers
   Furnish and install where digital display clocks are located in classrooms, offices, and hallways, etc.
2. Furnish and install Legrand TV2MW back box with (1) Category 6A data drop and duplex receptacle at each digital display clock.
3. Screen display orientation can be either Landscape or Portrait mode
4. Preloaded with operating system software
5. Communicates to the online Management Portal through wired or Wi-Fi network
6. Resumes normal operation after a temporary power interruption without intervention
7. Operator adjustable or scheduled screen brightness to reduce distraction
8. Scheduled sleep mode for energy conservation

B. Wall Mounting Hardware shall include the following features

1. Display wall mounting bracket kits for retrofit installations and new installations
2. Kits include tamper-resistant mounting brackets that allow tilting of the display in both portrait or landscape orientation, and integrated clip for the display power supply
3. A clear guard for common area applications protects displays, provides ventilation, and accommodates full mounting bracket tilt

C. Integrators shall include the following features

1. Integrators are wired to existing security system switches, and create internet messages that automatically trigger alert displays upon change of switch status
2. Each integrator supports physical wiring to monitor normally open (dry contact) security system switches, providing maximum reliability and fast response for automatically triggered alerts
3. Integrators can be configured to monitor fire alarm panels, lockdown switches, or any other normally open switches used for emergency alarm purposes

D. Software Service Agreement (SSA) shall include the following features

1. Provides access to the Management Portal and telephone technical support
2. Available for multi-year terms, renewable prior to expiration
3. Expiration of SSA will cause display to revert to synchronized clock function only: Emergency alert detection and notification, digital signage functions, including current weather, and technical support will no longer be available.

E. The Management Portal shall include the following features

1. General
   a. Three levels of user access-level rights, including Site Administrator/District, School, and Classroom
   b. Capable of uploading audio files for playback through the displays, including bells, tones, sirens, music, and prerecorded voice messages
   c. Supports automated email and/or text outbound notifications to a list of subscribers authorized by the site administrator upon alarm activation or loss of network connections between any display and the management portal

2. Emergency Alerts

a. Emergency alerts with audible tones and customized messages can be configured by the site administrator access level only: Fire drills and alerts, lockdown drills and alerts, severe weather drills and alerts, and custom alerts
b. Alerts override all other routine displays

3. Routine digital signage
   a. Routine messages be configured and deployed by all access levels: Time-synchronized event reminders, and audio alerts, including scheduled tone activation for class change notification, school start and dismissal
   b. Screen background customization
   c. Quiet message type to prevent distraction: Alert and higher level messages override quiet messages
   d. Instant messaging with notification tone
   e. Daily announcements, calendar events and scheduled activities
   f. Tagging support for content delivery to individual classrooms or tagged groups
   g. Weather advisories displayed as banners at the bottom of the screen

4. Clock display
   a. Analog or digital synchronized clock time.
   b. 4-digit or 6-digit digital clock display.
   c. Classroom and hallway countdown timer support.

5. Management Portal user interface for mobile devices
   a. Password protected access, 4-character PIN.
   b. Accessible from any online smart mobile device.
   c. Streamlined, responsive-design version of the management portal full user interface.
   d. Trigger fire, lockdown and weather, and custom alerts directly from a smart phone.
   e. Send all clear message.
   f. Send instant messages that override scheduled messages.
   g. Automatically documents the mobile device user who has activated an alert.

2.4 EQUIPMENT SPECIFICATIONS

A. Display, American Time p/n EADV1 including:

1. Dimensions, master shipping carton, two displays: 38” L, 8-3/8” W, 18-1/2” H
2. Weight, master shipping carton, two displays: 37lbs
3. Weight, single display: 12lbs
4. Dimensions, single display: 21” L, 1-3/8” W, 12-29/32” H
5. Dimensions, display screen diagonal: 21.5”
6. Lighting, screen: LCD with LED backlight
7. Resolution, display screen: 1920 x 1080
8. Mounting formats: Portrait or Landscape modes
9. Internal speakers: 2 each at 2W
10. Operating system: Android
11. USB ports: 2
12. External speaker output jack: 3.5mm
13. Wired Ethernet connectivity: 10/100M, RJ45 connector
14. Wireless Ethernet connectivity: Wi-Fi - 802.11b/g/n (2.4GHz)
15. USB provisioning: USB drive with AES encryption
16. Wired provisioning: LAN/DHCP Web portal on network connection
17. Time synchronization support: 2 static IP address SNTP servers
18. Clock battery backup for power outages: CR1620 Lithium

19. Relative humidity: 85%
20. Operating temperature: 0deg C – 40deg C
21. Input voltage to power supply: 100-240VAC, 50/60Hz
22. Power supply output voltage: 12Vdc
23. Energy efficiency: Level VI
24. Power Consumption: 30W (average), 40W (maximum), 23W (sleep)
25. Certifications: ROHS, CE/FCC, PSU with UL

B. Wall Mounting Hardware kits for easy display installation:

1. Surface mount bracket kit, ref American Time p/n EASMB
   a. Tilt bracket with standard VESA interface allows +/- 10 degrees of tilt.
   b. Integrated clip to hold display power supply
   c. Surface mount plate for new construction

2. Display guard, American Time p/n GRP17X25X10:
   a. Clear high-strength polycarbonate.
   b. Allows full +/- 10 degrees display mounting bracket tilt.

C. Integrator, American Time p/n EAIV1:

1. Wired Ethernet connectivity: 10/100M, RJ45 connector
2. Monitored switch style: Normally open dry contact
3. Number of monitored switches: 2 switches per Integrator
4. Number of Integrators per EverAlert system: 5 Integrators per system
5. Input voltage to power supply: 100-240VAC, 50/60Hz
6. Power supply output voltage: 12Vdc

D. Software Service Agreement, American Time p/n's EASSA1V1, EASSA2V1, EASSA3V1.

1. Allows customer access to the Management Portal and technical support.
2. Available with one, two or three-year renewable Software Service Agreements (SSA).
3. Expiration of SSA will cause display to revert to synchronized clock function only: Emergency alert detection and notification, digital signage functions, including current weather, and technical support will no longer be available.

E. Management Portal, American Time (no p/n)

1. Server location: Cloud
2. Application updates: Daily at 2:00am
3. Update re-boot time: less than 5 minutes
4. Compatible browsers as of December, 2016: Internet Explorer, Chrome and Safari
5. Ethernet connectivity: HTTPS secure connection to all devices.
6. Maximum number of simultaneous active users per site: Up to 100
7. Maximum number of email and text message subscribers: Up to 100
8. Clock synchronization and daylight saving time support: Configurable SNTP server addresses/pool domain names
9. Network credentials: AES encrypted key creation
10. Number of automatically triggered weather alerts: Up to 15
11. Max size MP3 audio files: 4MB per file
12. Total storage for all media per site: 500MB

2.5 SYSTEM OPERATION AND STARTUP SEQUENCE

A. Provide all connections to data network.

B. Displays is configured/provisioned by one of two optional methods.

1. Display configuration using wired LAN on a DHCP Network (option 1).
   a. Power-on device.
   b. Connect Ethernet cable to display.
   c. Display will automatically connect and provision to the correct site.

2. Display configuration using USB key (option 2)
   a. Login to portal and create a USB key by selecting create key and saving to a USB.
   b. Power-on Device.
   c. Insert USB stick.
   d. Display will automatically connect and provision to the correct site.

C. Integrator installation

1. Connect normally open contact closure switches of desired alarms to trigger on the Emergency Notification System integrator input 1 and/or input 2.
2. Login to portal and select new Emergency Notification System Integrator
   a. In the Management Portal, document the title, serial number, and desired inputs.
   b. Document instructions for display configuration when alarm is triggered for each Integrator input.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Construction must be complete, and rooms clean and dry where equipment is located.

B. Either a 110 VAC power outlet or legacy clock molex connector supplying 110 VAC power at the installation point is required for each display.

C. Wi-Fi or wired internet connectivity is required at each display location.

3.2 SYSTEM INSTALLATION

A. Install displays and integrators in accordance with manufacturer's installation manual furnished with the system, for proper installation of each system component.

B. Mounting brackets shall be securely attached to walls.

3.3 CLEANING

A. Prior to final acceptance, clean exposed surfaces of all system components, using cleaning methods recommended by the manufacturer.

B. Remove shipping packaging and other protective materials from the products.

3.4 FIELD INSPECTION

A. Prior to final acceptance, inspect each system component to function properly and replace parts that are found defective.

3.5 MANUFACTURERS SERVICES

A. Services are provided for the term of purchased Software Service Agreement.

B. Management portal software updates.

C. Remote technical assistance, on product start up, system setup, and system operation is provided via phone, fax, or e-mail.

3.6 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup checks according to the approved manufacturer's written instructions.

3.7 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct two 4-hour training sessions. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

C. Conduct four 4-hour training sessions. Train teachers and administration personnel on system operation.

3.8 SPARE PARTS

A. Furnish the following component at the end of the project to the Owner:

1. Display, American Time p/n EADV1 with mounting bracket: 10

End of Section

Section 27 53 19

PUBLIC SAFETY RADIO DISTRIBUTED ANTENNA SYSTEM (DAS)

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. It is the intent of these specifications that the Contractor, Manufacturer and/or its Authorized System Integrator expeditiously furnishes and installs a system complete in every respect and ready to operate. All miscellaneous items and accessories required for such installation, whether or not each such item or accessory as shown on the plans or mentioned in these specifications, shall be furnished, and installed.

B. This specification describes the criteria for deploying a Public Safety Radio Distributed Antenna System (DAS). The DAS components specified in this document include Bi-Directional Amplifiers (BDA), Donor Antennas, Coverage Antennas, Coax Cable, Coax Connectors, Splitters, Combiners and Couplers. These devices shall be used as part of a system, by the DAS integrator, experienced with designing projects for in-building, public safety, 2-way radio systems.

C. It shall be the integrator’s responsibility to base the system on the frequency ranges used by both Police and Fire departments and any proposal/submittal shall be reflective of advance investigation of this requirement. The system shall include a true, integrated battery backup unit which is serially connected to the main BDA system. Small UPS units not serially connected shall not be acceptable.

1.4 ABBREVIATIONS AND ACRONYMS

A. ACG: Automatic Gain Control

B. AHJ: Authority Having Jurisdiction

C. ATP: Acceptance Test Plan

D. BDA: Bi-Direction Amplifier

E. BOM: Bill-of-Material

F. DAS: Distributed Antenna System

G. EBS: Educational Broadband Service

H. ESMR: Enhanced Specialized Mobile Radio

I. FCC: Federal Communications Commission

J. GUI: Graphical User Interface

K. LMR: Land Mobile Radio

L. MTBF: Mean Time Between Failure

M. NFPA: National Fire Protection Association

N. NMS: Network Management System

O. PSN: Public Safety Network

P. RoF: Radio-over-Fiber

Q. RSL: Received Signal Level

R. SMR: Specialized Mobile Radio

S. SMS: Short Message Service

T. SNIR: Signal-to-Noise Interference Ratio

U. SOW: Statement of Work

V. VSWR: Voltage Standing Wave Ratio

1.5 DEFINITIONS

A. Acceptance: Expressed approval by the AHJ and owner's representative.

B. Specialty Trade Contractor: The Contractor experienced in the installation and commissioning of 2-way Public Safety Radio In-Building Systems.

1.6 FIRE DEPARTMENT SUBMISSIONS

A. The vendor will complete a Fire Alarm Permit Application acquired from the Fire Prevention Division stating a Bi-Directional Antenna "BDA" installation.

B. Plan Review: Provide one line, schematic and detail drawings of the proposed system architecture. Indicate proposed locations for system components. Provide specifications for procurement and installation of a complete system for review by the Fire Department and all other agencies and authorities having jurisdiction (included will be operational frequencies).

C. Testing and Commissioning: Coordinate the completion date of the Fire Department radio signal repeater system so as to permit a Certificate of Occupancy to be obtained in a timely manner, in accordance with a schedule established by the owner's project manager.

D. The entire system shall meet with the approval of the Fire Department and all other agencies and authorities having jurisdiction before a Certificate of Occupancy will be issued.

1.7 QUALITY ASSURANCE

A. Qualifications: The Integrator shall be an authorized reseller of the proposed system and shall employ NICET certified technicians.

1.8 CODES, STANDARDS AND CERTIFICATIONS

A. All work, including but not limited to: cabling, pathways, support structures, wiring, equipment, installation, workmanship, maintenance and testing shall comply with the latest editions of the National Fire Protection Association (NFPA), National Electrical Code, National Electrical Safety Code, all applicable local rules and regulations, equipment manufacturer's instructions, and the National Electrical Contractors Association (NECA) Standard of Installation. In case of discrepancy or disagreement between the documents noted above, the Contractor shall satisfy the most stringent requirements.

B. Requirements set forth by first-responder code, ordinance, or the AHJ shall supersede the requirements described herein and shall be met in their entirety. It is the Contractor's responsibility to ensure that the system complies with local code, ordinances or requirements established by the PSN AHJ.

1.9 SUBMITTALS

A. The Contractor, prior to beginning the on-site installation, is required to submit, for approval by the owner, a complete list of the proposed equipment with a system diagram showing how the various components are interconnected and their function. Included in the submittal shall be:

1. Prior to assembling or installing the system, the Contractor shall provide complete shop drawings which include the following:
    a. List the name of the manufacturer's local representative and his/her phone number.
    b. Table of contents.
    c. Manufacturer's parts lists
    d. Product serial numbers
    e. Catalog cut sheets
    f. Installation instructions
    g. Typical wiring diagrams
    h. Drawings showing equipment locations
    i. Manufacturer's warranty documents

2. All drawings shall be fully dimensioned.
3. Operating License: Submit evidence of application for FCC Radio Station Authorization prior to installing equipment when required for operation of the equipment.
4. Product Data: Submit manufacturer datasheets for the following components:
   a. Bi-Directional Amplifiers (BDA)
   b. Donor and Coverage Antennas
   c. Coaxial Cable and Connectors
   d. Splitters, Combiners and Couplers

5. Shop Drawings: Submit the following items:
   a. RF site survey results (initial and final surveys)
   b. System overview and riser diagram.
   c. Overlay of system components on floor plans.
   d. Donor Antenna lightning suppression and grounding details

6. Statement of Work (SOW): Submit a brief description of the DAS integrator role and responsibilities on this project. At a minimum, the services included shall be to perform the RF survey, systems design, test, optimization, and commissioning of the DAS system
7. Acceptance Test Plan (ATP): Submit a proposed ATP including cable testing reports.

B. Submittal Requirements at Close Out

1. Drawings: Submit as-built drawings indicating:
2. A final, signed copy of all previously submitted documents reflecting the final, as built.
   a. representation, equipment used and details.
   b. Cable routing, splitters, couplers, and coverage antenna final locations.
   c. Active component locations, layout, configuration, and programmed parameters.

3. Test Reports
   a. Submit Accepted ATP reports.

4. Field Reports: Submit sweep-testing results for all cable runs.
5. Field Reports: Submit OTDR test results for all fiber runs.
6. Operation and Maintenance Data: Submit hardware and software manuals for all Active Components.
7. Warranty Documents:
   a. Submit for all manufactured components specified in this Section.
   b. Submit Contractor's System Warranty.

1.10 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers

1. RSI.
2. Honeywell.
3. CommScope/Andrew.
4. Or approved equal.

2.2 BASIS OF DESIGN

A. The system specified is based upon RSI Signal Booster and represents the performance standard upon which any equivalent solution shall be based.

2.3 SYSTEM DESCRIPTION

A. General

1. The system must utilize only Class A Signal Boosters'
2. The distributed antenna system may be a radiating cable, fixed antennas or a combination of both.
3. The system must comply with all applicable sections of FCC Rules.
4. Permanent external filters or attachments shall not be permitted.
5. Assembly/installation of all components shall comply with the National Electrical Code.
6. Survivability from attack by fire shall meet NFPA 72.
7. All system components shall be installed, tested, inspected, and maintained in accordance with the manufacturers' published instructions.
8. The system design, and installation, shall not exceed the FCC's OET 65 standards.
9. The system shall be normally powered on and continuously provide passing of required frequencies.
10. Shall be compatible with both analog and digital communications, simultaneously at the time of installation.
11. BDA systems shall have lightning protection that complies with NFPA 780.
12. Maximum propagation delay is 15us (microseconds).

2.4 SIGNAL STRENGTH

A. A minimum inbound (downlink) signal strength of -95 dBm shall be provided throughout the coverage area. The inbound signal level shall be sufficient to provide a minimum of DAQ 3.0 for either analog or digital signals.

B. A minimum outbound (uplink) strength of -95 dBm shall be provided at the Fire Department receivers. The outbound signal level shall be sufficient to provide a minimum of DAQ 3.0 for either analog or digital signals.

2.5 ISOLATION

A. Antenna isolation shall be maintained between the donor antenna and all inside antennas to a minimum of 20dB under all operating conditions.

2.6 PATHWAY SURVIVABILITY

A. Levels shall be as described in Section 5.10. (IFC, 2015)

B. Radiating cable shall not be required to be installed in metal raceway.

C. Feeder and riser coaxial cables shall be rated as plenum cables.

1. Feeder coaxial cables shall be connected to the riser coaxial cable using hybrid coupler devices of a value determined by the overall design.
2. Riser coaxial cables shall be rated as riser cables and routed through a 2-hour-rated enclosure.

D. The connection between the riser and feeder coaxial cables shall be made within the 2-hour-rated enclosure, and passage of the feeder cable in and out of the 2-hour-rated enclosure shall be fire-stopped to 2-hour ratings.

2.7 NON-INTERFERENCE AND NON-PUBLIC SAFETY SYSTEM DEGRADATION

A. No amplification system capable of operating on frequencies or causing interference on frequencies assigned to the Fire Department by the FCC shall be installed without prior coordination and approval of the Fire Department.

B. The property owner shall suspend and correct equipment installations that degrade the performance of the Boston Fire radio system or the BDA.

C. BDA Systems that share infrastructure with non-public safety services shall ensure that the coverage and performance of the public safety communications channels are not degraded below the required level of performance, regardless of the amount of traffic carried by the nonpublic safety services.

D. Secondary users must furnish a complete list of transmit and receive frequencies along with an intermodulation (IM) study that will accompany the permit application. The IM Study will consist of the following calculations: IM=Q*F, IM=F1+F2+F3, IM=F1+F2-F3, IM=Q1*F1+Q2*F2, and IM=Q1*F1-Q2*F2 for all frequencies up-link and down-link. These calculations will be done to the 5th order.

2.8 SYSTEM RADIO FREQUENCIES

A. The BDA shall be capable of transmitting all radio frequencies, assigned to the Fire Department, and be capable of using any modulation technology in current use by the Fire Department.

2.9 FREQUENCY CHANGES

A. The BDA system shall be upgradeable to allow for changes or additions to system frequencies to maintain radio system coverage as it was originally designed.

2.10 RADIO SURVEY

A. The system vendor shall test the in-building radio system ensure that two-way radio coverage on each floor of the building meets or exceeds the required signal strength.

B. Each floor of the building shall be divided into a grid of approximately twenty (20) equal areas. A maximum of two (2) areas will be allowed to fail the test per floor. A spot located approximately

in the center of a grid area will be selected for the test. Once the spot has been selected, prospecting for a better spot within the grid area will not be permitted. Field strength testing instruments are to be calibrated annually and of the frequency selective type incorporating a flexible antenna similar to the ones used on Fire Department handheld transceivers.

C. RF plots indicating the initial assessment of radio coverage and the enhanced coverage shall be submitted at the time of acceptance testing.

D. All compliance testing to be done with 50 ohm loads in place of the donor antenna to avoid interference to the Fire Department radio system.

E. Unattended operation of the BDA is not permitted until the completion of acceptance testing.

2.11 REQUIREMENTS

A. On a per channel basis, the downlink RSL for each frequency band shall meet or exceed Design Audio Quality (DAQ) testing criteria.

B. The DAS shall deliver coverage throughout 95% of the building, and 99% of areas designated as critical. Critical areas include fire command centers, fire pump rooms, exit stairs, exit passageways, elevator lobbies, standpipe cabinets, sprinkler sectional valve locations, and other areas deemed critical.

C. The system shall be housed in a NEMA 4 cabinet and shall include 24-hour battery backup.

D. The system shall maintain maximum required output power while preventing excessive emissions per FCC requirements.

E. Antenna locations as shown on the drawings are approximations. The Integrator is responsible for locating the in-building antennas and the donor antenna as required by the equipment selected, proposed design and the design criteria.

2.12 POWER SUPPLY

A. The central equipment shall be supplied with an emergency power unit including batteries and battery charging equipment that maintains this cabinet and all outlying equipment that requires power operation without any change in status for a minimum period of twenty-four (24) hours. The emergency power units(s) shall be sized to meet the following minimum requirements: operating in normal (supervisory) mode, twenty-four (24) hours, followed by twelve (12) hours of emergency operation. Batteries shall be of the sealed maintenance free type.

B. System design shall be such that neither the failure of the normal power source, the transfer to an emergency source, nor the retransfer to the normal source shall cause a change in system status.

C. At least two independent and reliable power supplies shall be provided for all RF emitting devices and any other components of the system.

D. The Primary Power Source Shall be supplied from a dedicated branch circuit and comply with NFPA 72.

2.13 EQUIPMENT LOCATION AND PROTECTION

A. Secured Space: The bi-directional radio amplifiers shall be installed in 2-hour rated closet. They shall be located in a suitable non-finished space as approved by the engineer and/or where specifically shown on the drawings. The entrance to the secured space shall clearly identify the space as having the “Fire Department” radio signal repeater equipment, by the use of an attached engraved nameplate.

B. All BDA components, RF filters, and battery system components shall be contained in a NEMA4- or NEMA4X-type enclosure(s).

C. The cabinet shall be large enough to dissipate internal heat without venting the inside of the cabinet to the outside atmosphere. External or exposed RF filters are unacceptable.

1. Dedicated battery cabinets may be vented.

D. The cabinet shall be painted red and equipped with a locking mechanism.

E. The cabinet shall be labeled (in bright yellow):

FIRE DEPT. RADIO
BDA Permit #
Serviced by: (Vendor Name)
(Vendor Phone)

2.14 SYSTEM MONITORING

A. A sign will be located at the dedicated monitoring panel with the name and telephone number of the radio service provider indicating that they shall be notified of any alarm.

B. Trouble signals must be immediately reported to the radio service provider.

C. The Fire Department must be notified of any failures that extend past the two (2) hour time limit.

D. The building's Fire Alarm system shall include automatic supervisory signals for malfunctions of the BDA system that are annunciated by the fire alarm system in accordance with NFPA 72, and shall comply with the following:

1. Monitoring for integrity of the system shall comply with NFPA 72, Chapter 10.
2. System supervisory signals shall include the following:
   a. Donor antenna malfunction
   b. Active RF emitting device failure
   c. Low-battery when 70% of the 12-hour operating capacity has been depleted
   d. System component failure

3. Power supply supervisory signals shall include the following for each RF emitting device and system component:
   a. Loss of normal ac power
   b. Failure of battery charger

4. The communications link between the fire alarm system and the BDA must be monitored for integrity.

E. A dedicated monitoring panel shall be provided within the fire command center to annunciate the status of all RF emitting devices and system component locations. The monitoring panel shall provide visual and labeled indications of the following for each system component and RF emitting device:

1. Normal ac power
2. Loss of normal ac power
3. Battery charger failure
4. Low battery capacity (to 70 percent depletion)
5. Donor antenna malfunction
6. Active RF emitting device malfunction
7. System component malfunction

F. The communications link between the dedicated monitoring panel and the two-way radio communications enhancement system must be monitored for integrity.

2.15 COMPONENTS

A. Low Profile Omni-Directional DAS Antenna

1. Model Number: BDA-FA-7800-1 (DAS Antenna)
2. Model Number: BDA-FA-7800-2 (DAS Antenna, Indoor/Outdoor)
3. Model Number: BDA-LP-7800-1 (DAS Antenna, Indoor)

B. Ultra-Wideband DAS Antenna

1. Model Number: BDA-LPA-4502700-1 (DAS Antenna, Indoor)

C. Directional Panel Antenna

1. Model Number: BDA-DP-7800-2 (DAS Antenna, Indoor/Outdoor)

D. Donor Antenna - Outdoor

1. Model Number: DA-7800-1
2. Model Number: BDA-DA-LP582700-1

E. Bi-Directional Amplifier (BDA):

1. Electrical Specifications
   a. Frequency Range: 806-815MHz UL / 851-860MHz DL
   b. Maximum Gain (adjustable): 92dB max. (90dB typ.)
   c. Gain Adjustment. 1 dB steps: 50dB to 92 dB = 42 dB total adjustment range
   d. Maximum Composite Output Power (i.e., single carrier max. power): 32dBm max. 31dBm typ.
   e. Power Limiter Adjustment (1 dB increments): 30dBm to 16 dBm
   f. Impedance: 50 Ohm
   g. Maximum RF Signal Input Level for FCC spurious limits compliance: -20dBm
   h. Absolute Maximum Input RF Signal Level: 0dBm continuous, +10dBm peak
   i. Noise Figure: < 6.5dB typ. 8dB max.
   j. Alarms: Two Form C relays for each of the alarms: AC Power Status, Charger Status, Low Battery Capacity, Low Battery Voltage, BDA Trouble, Antenna Trouble and Aux Alarm. Second relay contact set provided for a LED annunciator panel.

k. Alarm Logging: Standard SD Card up to 16GB. Mini SD with adaptor. Realtime clock time stamp included.
l. AC Power Supply: Two independent power supplies with 110-240VAC/2.1A or 277VAC/0.8A 50/60Hz each.
m. Power Supply Efficiency 93% (Typ.)
n. DC Power Supply: UL-60950 Listed, supports either 2x75Ah 12V AGM Sealed L.A. Batteries in series for DC UPS Backup or an external 28VDC Supply. Max. Current Draw: 2.15A & > 24-28VDC
o. Run Time with standard 2x75Ah Battery Backup: > 25-30 Hours under full load.
p. Battery Charging with the Built-in Charger: UL-609SO Listed, Charging Current Limited to 4A max. Float voltage: 27.4V
q. Operating Temperature Range: -30°C to +6S°C
r. Recommended Ambient Temperature: -20°C to +35°C (-4°F to +95°F)

2. Mechanical Specifications
   a. Dimensions: NFMA4 enclosure:
      1) 20"W x 24"H x 7"D
      2) Total Width Including Heatsinks: 24"
      3) Total Height Including Mounting Tabs: 26"
   b. Signal Booster Enclosure Type: NEMA-4, Sealed Enclosure, Aluminum with Powder-Coat or Enamel Finish. Red for NFPA-Compliant Mission-Critical BDA Version and Beige for others. UL-Listed enclosure version available.
   c. Weight - Standard Enclosure, Single Band Configuration, NFPA Compliant Version with two power supplies: <55 lbs.
   d. RF Connectors: N-Female
   e. Booster Shipping Box Size: 30" x 30" x 15" – UPS, FedEx Shippable
   f. Backup Battery Enclosure (Applies to NFPA-Compliant Version of the Booster): 22"W X 13"H X 8"D
      1) Contains two 12V/75Ah Sealed Lead-Acid Batteries.
      2) Enclosure Color: Beige
      3) Includes Louvered Vents on Both Sides
   g. Connections: Four 1/2" trade size cutouts provided for conduit or strain relief fittings for power, battery backup and alarm lines.

F. BDA Status Annunciator

1. Model Number: ANP-11A

G. Cable:

1. 2-Hour Fire Rated Cable: AFW-2HFR-3, American Fire Wire® Low Loss 2-Hour Rated Coaxial Cable, braided copper, 1/2 in, red LSZH polyolefin jacket.
   a. Install 2-hour rated cable from the antennas on the roof to the BDA, and from the BDA to the first antenna on each floor.

2. Plenum Rated Cable: AL4RPV-50, Commscope HELIAX® Plenum Rated Air Dielectric Coaxial Cable, corrugated aluminum, 1/2 in, Red PVDF jacket.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Donor Antenna Considerations & Mounting

1. Antenna shall be mounted free and in the clear.
2. Antenna shall be mounted away from all power lines.
3. Antenna shall be Yagi type with approximately 10dbi gain.
4. The antenna is typically mounted on the wall or roof of the side of the building with the strongest signal.
5. It is recommended to install antenna on opposite side of building from closest DAS antenna to eliminate the possibility of isolation related oscillation issues.
6. The exterior antenna must not be co-located or operating in conjunction with any other antenna.
7. Support mast shall not be EMT. Mast shall be rigid pipe, galvanized water pipe or antenna mast.
8. Mounts shall be manufactured to hold antenna mast, and galvanized.
9. Antenna shall be a minimum of 3’ and a maximum of 6’ from roof so as not to encumber additional snow and ice load.
10. Support mast shall have a minimum of two clamps to affix to mount.
11. Mounts shall be sufficiently spaced so as to minimize torque and bending moment.
12. Support mast shall be mounted to a rigid surface so as not to require guy wires.
13. Support mast shall be plumbed vertical.
14. Antenna shall be pointed only at the prime site even if higher RSSI is found at another azimuth.
15. Antenna shall be mounted for vertical polarization.
16. Any drip/weep holes shall be installed to face down.
17. When at all possible, antenna design shall be a fully enclosed radome over driven element(s) & feed point.
18. Antenna support mast shall be grounded to building steel directly. Refer to proper NEC regulations.
19. Exterior antenna connections shall be courtesy wrapped with tape, wrapped with butyl mastic, and sealed with High Quality UV stable wrap. The courtesy wrap shall allow connection to be sliced open without leaving mastic on connectors so as to enable future service if needed.
20. Antenna cable bend radius shall not exceed manufacturers recommended radius for cable.
21. Antenna surge arrestor & cable ground kit shall be mounted as close to building penetration as possible and grounded to building steel. Refer to proper NEC regulations.

B. DAS antenna/splitter(s)

1. Sufficient antennas & BDA gain shall be provided so as to prevent issues with “near/far” effect.
2. There shall be a minimum of 20db isolation between outdoor donor antenna and indoor das antennas at all times.
3. Omnidirectional antennas shall be mounted free and in the clear, preferably in the center of the room or area they are to cover.
4. Flat panel antennas shall be wall-mounted as close as possible to the center of the wall, or at one end of long narrow space.
5. Dome antennas are mounted on the ceiling as close to the center of the desired coverage area as possible, domed (convex) side pointing down.

6. If suspended ceilings are used in the building, all DAS antennas shall be mounted inverted in the center of a room or hall ceiling.
7. It is important to keep the cable runs equal or use taps to ensure a harmonious install.
8. Verify that all interior antennas meet the separation requirements needed for proper system function, and that no antenna is aimed towards the exterior donor antenna.
9. Manufacturer mounting instructions shall be followed. If antenna/splitter mount has 4 holes to mount, then 4 holes shall be utilized at all times.
10. In no cases are unapproved cable hangers to be used. Manufacturers spec cable hanger listed for the type of cable shall be utilized. Tyraps are not permitted to hang cables.
11. Interior DAS antennas, and cables shall be mounted with their own mounts and shall not be tyrapped or held in place with anything other than manufacturers approved clamping devices. There is to be no clamping of antennas or cables etc. to existing interior piping such as sprinkler, air, gas etc. pipes.
12. All cables & antennas shall have their own independent means of support.

C. Antenna Cable installation

1. Antenna cable shall be affixed at a minimum of every 48” using cable manufacturer approved clamps designed for the cable directly.
2. Manufacturers published instructions shall be used in providing independent support and protection from physical damage.
3. Manufacturers minimum bend radius shall be followed for all cables.
4. Use appropriately rated sealant/caulking to waterproof/fireproof interior or exterior cable entry points.
5. All perforations through walls shall be sleeved with conduit to avoid cable damage.
6. Antenna cable shall be marked “Fire Dept BDA” in clearly readable letters. Markings shall be at approximately every 10 feet and especially at any point where cable could be damaged by contractor on site work.
7. Antenna cable shall not be deformed in clamps.
8. Antenna cable shall be properly supported within 12” of BDA connections.
9. Antenna cables shall have proper service loops installed so as to eliminate possibility of damage when performing service on unit.
10. Splitters shall have 50-ohm resistive loads installed on any output tap which is un-used.
11. Antenna connector ferrules shall be finger-tight and not improperly torqued with pliers/wrenches etc.
12. Antenna cabling shall not be bundled or ran with other cables under any circumstances.

D. BDA Installation

1. BDA location shall be walk-up access and shall not require a ladder to service.
2. BDA shall be located in a 2-hour fire rated location.
3. BDA location shall not be encumbered by other building infrastructure so as to limit service or installation.
4. BDA location shall not be in a tightly enclosed or overly hot space.
5. BDA Power and warning lights shall be easily visible.
6. Annunciators shall be manufacturer rated for use with BDA.
7. BDA shall be mounted on wall with piece of plywood and unistrut to support BDA enclosure.
8. BDA Battery backup shall be manufacturer approved and UL listed for operation with BDA.
9. Backup battery shall be mounted in a minimum of a NEMA 3R metal enclosure, plastic enclosures are not allowed.
10. BDA alarm wiring shall have proper pull-up resistors so as not to cause errant fire alarm activation in the event of loss of AC power.

E. Post Installation

1. Installer shall be fully equipped to demonstrate isolation level between interior DAS antennas and outdoor Donor antennas to Fire Department personnel. Isolation should be tested both ways, donor-DAS and DAS-donor antennas. Measurements of incoming signal from Prime Site and outgoing to DAS will be checked and noted. A complete site walk will be conducted and measurements for RSSI will be conducted at each DAS antenna and grid square testing will be spot checked in the worst areas for signal quality. Uplink levels at all DAS antennas will be measured via remote spectrum analyzer. Alarms will need to be demonstrated with proper NFPA alarm name reporting to the Fire Alarm Panel under Fire Department direction.
2. BDA shall be run on battery during inspectional testing and grid square testing for verification of -95 dBm levels.
3. In NO event is an installed system to be powered on even for testing without authorization/notification to the Fire Department.

3.2 INSTALLER QUALIFICATIONS

A. Approved Radio Service Provider

1. An approved Radio Service Provider is a company whose normal course of business involves the installation, repair and servicing of portable radios, mobile radios, signal boosters, base stations, and associated infrastructure.

B. Senior Technician

1. The Design, Installation and Commissioning shall be conducted, documented, and certified by a radio technician who is in possession of all of the following:
   a. FCC General Radiotelephone Operator License.
   b. ETA Senior Certified Electronics Technician (CETsr) or equivalent Certification from an industry organization acceptable to the Fire Department.
   c. Manufacturer's Certification.

C. Radio Technician

1. The inspection, repair and preventative maintenance shall be conducted, documented, and certified by a radio technician who is in possession of all of the following:
   a. FCC General Radiotelephone Operator License.
   b. ETA Certified Electronics Technician (CET) or equivalent Certification from an industry organization acceptable to the Fire Department.
   c. Manufacturer's Certification.

D. Radio service providers will be issued call signs for use when transmitting on the Fire Radio System.

E. Annual inspection reports and 5-year RF Surveys must be submitted to the Fire Department in a timely manner.

F. The Fire Department shall be notified in writing at least thirty (30) days prior to cancellation of a maintenance contract. Such notice shall contain the date and time such cancellation is to take effect, BDA location, and BDA Permit #.

G. The Fire Department Radio Supervisor shall be notified in writing upon the procurement of contractual agreements relating to in-building radios covered by this specification.

3.3 GROUNDING PROCEDURE

A. In order to minimize problems resulting from improper grounding, and to achieve maximum signal-to-noise ratios, the following grounding procedures shall be adhered to.

B. System Ground: A signal primary “system ground” shall be established for the system. All grounding conductors in that area shall connect to this primary system ground. The system ground shall consist of a copper bar of sufficient size to accommodate all secondary ground conductors. An extension of the ground shall connect to the buildings lightning protection system.

C. A copper conductor, having a maximum of 0.1 Ohms total resistance, shall connect the primary system ground bar to the primary system ground ring.

D. Secondary system grounding conductors shall be provided from all racks, radio consoles, and undergrounded radio equipment in each area, to the primary system grounding point for the area. Each of these grounding conductors shall have a maximum of 0.1 Ohms total resistance.

E. Under no conditions shall the AC neutral conductor, either in the power panel or in receptacle outlets, be used for a BDA system ground.

F. Radio cable Shields: All radio cable shields shall be grounded at both ends.

G. General: Because of the great number of possible variations in grounding systems, it shall be the responsibility of the installer to follow good engineering practice, as outlined above, and to deviate from these practices only when necessary to minimize crosstalk and to maximize signal to-noise ratios and reduce interference in the radio systems.

3.4 CABLE AND CONDUIT

A. Note the following circuitry requirements:

1. Conduit intended for use with the firefighter’s communication bi-directional radio amplifier system shall be steel electric metallic tubing (EMT), except as follows:
    a. It shall be galvanized steel intermediate conduit where mounted within 8’-0” of the floor in mechanical spaces or otherwise exposed to mechanical damage, or where intended for embedment in concrete.
    b. It shall be galvanized steel intermediate conduit if local authorities prohibit use of EMT.
    c. It shall be rigid galvanized steel conduit for the power supply to the central equipment and to all outlying equipment cabinets requiring a 120-volt or 120/208-volt supply.

2. All cables shall be installed in conduit.

3.5 ACCEPTANCE TESTING

A. Delivered audio quality (DAQ) testing will be conducted by Fire Department radio personnel to ensure that two-way radio coverage, on each floor of the building, meets the minimum coverage requirements. Tests will be scheduled with at least 5 days advance notice.

B. It is the building owner's responsibility to ensure that acceptance testing occurs prior to Fire Alarm System testing for the building.

C. At the time of this test, the following are also required:

1. The approved radio technician shall certify that the in-building radio system was installed and tested in accordance with the requirements of the current Fire Department In-Building Radio Specification.
2. An approved radio service company shall certify that a maintenance contract is in effect that provides 24 hour by 7 day response within 2 hours of notification of a problem. This contract must be for a period of at least 1 year.
3. RF Survey results, gain values of all amplifiers including screen shots.
4. Small scale drawings (11" x 17" maximum) of the structure shall be provided by the owner/contractor. The plans shall show each floor divided into the grids. Each grid shall be labeled to indicate the DAQ result from the RF Survey.
5. As built drawings (if needed)
6. BDA Manufacturer, Model #, Serial #, FCC Certification #
7. Link budget

3.6 TESTING PROCEDURES

A. For testing system signal strength and quality, the testing shall be based on the DAQ system. A DAQ level below 3.0 shall be considered a failed test for a given grid cell.

B. Delivered Audio Quality Definitions:

1. DAQ 1: Unusable, speech present but unreadable.
2. DAQ 2: Understandable with considerable effort. Frequent repetition due to noise / distortion.
3. DAQ 3: Understandable with slight effort. Occasional repetition required due to noise/distortion.

C. A number of cells per floor shall be selected at random. Signal strength measurements shall be taken at the center of each cell.

D. A maximum of two grid cells per floor will be allowed to fail the test. In the event that three of the areas fail the test, in order to be more statistically accurate, the testing grid resolution maybe doubled. If the number of grid cells is adjusted, the number of failed cells permitted shall be adjusted accordingly to meet the 90% coverage requirement.

E. Failures shall not be allowed in critical areas, including but not limited to the Fire Command Center, Fire Pump Room, Emergency Generator Room, Stairwells with a standpipe, Elevator Lobbies serving the Emergency Elevator, and other areas as identified by the Fire Department.

F. Both inbound and outbound signals shall be measured on each and every floor above and below ground including stairwells, basements, penthouse facilities and parking areas of the structure.

G. Measurements shall be made with the antenna held in a vertical position at three (3) to four (4) feet above the floor, (portable radio worn on the belt or turnout coat pocket).

3.7 ANNUAL TEST

A. All active components of the in-building radio system, including but not limited to amplifier, power supplies, and back-up batteries, shall be inspected a minimum of once every twelve (12) months.

B. Annual tests will be conducted by an authorized company.

C. Amplifiers shall be tested to ensure that the gain is the same as it was upon initial installation and acceptance. The original gain shall be noted and any change in gain shall be documented.

D. Back-up batteries and power supplies shall be tested under load for a period of one (1) hour to verify that they will operate during an actual power outage.

E. Active components shall be tested to verify they are operating as designed by the manufacturer.

F. If communications appear to have degraded or if the tests fail to demonstrate adequate system performance, the owner of the building or structure is required to remedy the problem and restore the system in a manner consistent with the original approval criteria.

G. The re-testing will be done at no expense to the City as required in the original testing procedures.

3.8 FIVE YEAR RF SURVEY

A. An RF Survey be conducted a minimum of once every five (5) years to insure that the radio system continues to provide the required level of radio coverage.

B. The procedure set forth in Section L shall apply to such tests.

3.9 MAINTENANCE & SERVICING

A. At final acceptance the building owner shall supply a letter to the Fire Department accepting the property owner's responsibilities. These responsibilities are as follows:

1. Upgrades to system as directed by the Fire Department.
2. Maintenance contract in place with name of authorized company, who will provide a 24 hour by 7-day emergency response within two (2) hours after notification. The system shall be maintained in accordance with FCC requirements.
3. Maintain a list of contact personnel with phone numbers at the BDA cabinet. The contact personnel shall have knowledge of the building and the BDA system and be available to respond to the building in the case of an emergency.
4. Annual Inspections.
5. 5-year RF surveys.
6. This letter is to be on company letterhead signed by the property owner or a legal representative.

3.10 MODIFICATIONS

A. Modification of an existing BDA System requires prior approval from the Fire Department.

B. A permit application shall be submitted which includes a description of the work to be performed and drawings showing intended modification.

C. Modification work must not degrade radio coverage at any time.

D. An RF Survey must be completed and submitted after any modification to an existing antenna system.

3.11 FIRE DEPARTMENT INSPECTIONS

A. Fire Department Radio personnel, after providing reasonable notice to the owner or their representative, shall have the right to enter onto the property to conduct field testing to be certain that the required level of radio coverage is present.

3.12 COMMISSIONING

A. Comply with requirements specified in Division 1.

B. Engage a factory-authorized service representative to supervise and assist with startup service. Complete installation and startup checks according to the approved manufacturer's written instructions.

3.13 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct two 4-hour training session. Train the Owner’s maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

C. Training shall include fire department personnel.

End of Section

Section 28 10 00

UNIFIED SECURITY SYSTEM

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

TO BE ISSUED BY ADDENDA

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. It is the intent of these specifications that the Contractor, Manufacturer and/or it's Authorized System Integrator expeditiously furnishes and installs a system complete in every respect and ready to operate. All miscellaneous items and accessories required for such installation, whether or not each such item or accessory as shown on the plans or mentioned in these specifications, shall be furnished and installed.

B. The unified security system shall be installed as shown on the drawings and as specified herein. The work covered by this section of the specifications includes the furnishing of all labor, equipment, materials and performance of all operations associated with the video surveillance system for a fully functional system.

C. It is the intention of this specification that the Access Control System (ACS), Intrusion Detection System (IDS), and Video Surveillance System (VSS) all be integrated on a software level such that any workstation so designated will have operational and/or display capability of the three combined systems under one software platform.

D. The school district has standardized on the Genetec VMS, HID ACS, Bosch IDS, Axis cameras and video entry system. The district already has all the core services setup at the network operation center. The district's licensing vendor is Siemens Security.

1. This contractor shall procure all system licenses from Siemens Security to maintain the district's licensing agreements.
2. Siemens Security point of contact is: Jon Hipsh, telephone: 857-205-7598, email: jonathan.hipsh@siemens.com.

Section 28 31 11

ADDRESSABLE FIRE-ALARM SYSTEM

(TRADE CONTRACT REQUIRED AS PART OF SECTION 26 00 01)

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. PUBLICLY BID TRADE CONTRACT REQUIREMENTS: As provided under Section 26 00 01 - ELECTRICAL and supplemented under the Bidding Requirements, Contract Forms, and Conditions of the Contract, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1. Work of this Trade Contract includes all individual specification sections listed in Section 26 00 01.

1.2 RELATED DOCUMENTS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.3 SUMMARY

A. The following requirements shall apply to the project:

1. System Design and Installation
   a. The equipment supplier and installer shall review all certified "Tier 1" Construction Documents (including plans, specifications and Fire Protection Design Narrative), and be responsible for the preparation of complete system installation and design submittal that will be submitted in the form of "Tier 2" Installation Shop Drawings.
   b. The installation submittal shall clearly indicate all proposed equipment and devices (type and quantity), with wiring diagrams showing circuits, cabling and wire types, detailed operational sequences, and interfaces to related systems.

2. Alarm Initiation:
   a. Automatic smoke detection shall be installed where shown and required, to include at all Fire Alarm Control Units, elevator landings and machine rooms, electrical and similar equipment rooms, and where otherwise required to initiate fire safety functions intended to control the spread of smoke. Heat detectors may be an acceptable substitution where ambient conditions preclude the use of smoke detectors.
   b. Manual pull stations shall be provided at the entrance to each floor exit, horizontal exits, and adjacent to the main Fire Alarm Control Panel. Travel distances to manual pull stations shall not exceed 200'.
   c. All sprinkler water flow and supervisory tamper switches, and fire suppression systems that serve the building shall be monitored by the building fire alarm system for alarm, supervisory and trouble conditions. This shall include supervision of water-based sprinkler systems, pre-action systems, kitchen hood suppression, and other special hazard suppression systems provided under Division 21.
   d. Smoke detection will be provided to release doors located on smoke barriers that are held open or are provided with power-operators. Upon activation of the local

smoke detector, the doors shall be released, and power-operators shall be disabled to control the spread of smoke across the barrier.

e. Duct smoke detection will be provided at the following locations:
   1) In all Supply air systems with a design capacity greater than 2000 CFM and located in a serviceable area downstream of any filters and ahead of any branch connections. Activation of the detector shall cause the unit to shut down and shall be closely coordinated with Division 23 control sequences.
   2) In all Return air systems with a design capacity greater than 2000 CFM, located in a serviceable area downstream from the last duct inlet. Activation of the detector shall cause the unit to shut down and shall be closely coordinated with Division 23 control sequences.
   3) At each connection to a vertical duct or riser serving two or more stories from a return air duct or plenum.

f. Smoke detection will be provided at all smoke dampers or combination fire/smoke dampers to initiate damper closure in the event of smoke detector activation, with programmed override closely coordinated with Division 23 control sequences.

3. Occupant Notification and Event reporting
   a. Audible notification appliances will be uniformly spaced, installed, and adjusted to produce a minimum sound level of 15dbA above average ambient throughout all occupied areas of the building.
   b. The average ambient sound level is anticipated to be 60dbA in all public and common use areas and 75dbA in Mechanical Equipment Rooms. Corresponding evacuation signal sound pressure levels are intended to be approximately 75-80dbA and 90-95dbA in Mechanical Equipment Rooms respectively.
   c. Voice Instructional messages shall be intelligible to comply with NFPA 72 and shall be subject to performance testing in designated Acoustically Distinguishable spaces as shown and specified herein.
   d. Visual notification appliances will be installed in all public use areas and common use areas. Common use areas include all interior and exterior spaces available to the public, in addition to circulation paths, rooms, or areas, and common use work areas that are unassigned or available for the use of two or more individuals.
   e. Alarm shall be reported to the City of Worcester Fire Department via radio masterbox.

4. Fire Safety Functions
   a. Emergency elevator functions will be provided to include Phase 1 elevator recall, manual hoistway/machine room vent operation, and firefighter’s hat indicator in accordance with applicable Code.
   b. The system shall include the required interface with all door hardware and security equipment to automatically disable power-operators, release held-open doors, or bypass any delayed egress or special locking arrangements along egress corridors to allow uninhibited egress during a building alarm.
   c. Manual override and control of all air distribution systems will be provided via hand-off-auto (HOA) switches located at the main FACP/Fire Command Center.
   d. A graphic Fire Fighter's Smoke Control Panel (FSCP) will be provided for all required dedicated and non-dedicated Smoke Control Systems.
   e. Auxiliary control of post-event smoke removal sequences shall be provided.

5. System Integration
   a. Discrete supervised programmable inputs and outputs shall be provided to serve as the required interface between systems, including Division 21 fire protection systems and Division 23 building automation systems. Alternative serial data or equivalent IT-based interface between systems may be permitted where otherwise

shown or specifically allowed by the Owner's representative and other Authorities Having Jurisdiction (AHJ).

6. System Installation and Acceptance
   a. All circuits, wiring, devices, and terminations shall be clearly identified and tagged as shown and specified and documented on the required as-built Record Documents.
   b. The system installer shall work with the system supplier/designers to ensure all equipment is installed as shown in the Shop Drawings and manufacturer's requirements and programmed to comply with the project requirements.
   c. The installing contractor is responsible for coordination with related trades, and complete (1st party) testing of the system as installed, to include verification that the system performs as intended, and all devices and fault conditions are properly supervised and reported as specified herein.
   d. Projects requiring third party testing do not relieve the Contractor of their responsibility for full and complete 1st party system testing and documentation as stated herein. It is the Installing Contractor's responsibility to ensure all 1st party testing is complete before any Engineer of Record, 3rd party, or local AHJ acceptance testing is to be conducted.
   e. The Contractor shall coordinate and track changes to the Tier 2 installation shop drawings during construction, modify the documentation changes throughout construction, and provide complete Tier 3 as-built Record documentation at project closeout.

1.4 RELATED WORK

A. The Contractor shall coordinate work in this Section with all related trades. Work and/or equipment provided in other Sections and related to the fire alarm system shall include, but not be limited to:
   1. Sprinkler waterflow and supervisory switches shall be furnished and installed by the fire protection contractor but wired and connected by the electrical contractor. Modification of existing sprinkler devices to accommodate monitoring by the new fire alarm system shall be the responsibility of the fire alarm system installing contractor.
   2. Duct smoke detectors shall be furnished, wired and connected by the electrical contractor. The HVAC contractor shall furnish necessary duct opening to install the duct smoke detectors.
   3. New air handling and smoke exhaust system fan control circuits and status contacts to be furnished by the HVAC control equipment.
   4. Elevator recall control circuits to be provided by the elevator control equipment. Modifications to the existing elevator controls to accommodate ANSI A17.1 shunt trip activation shall be provided by the elevator controls contractor. Any shunt trip circuit breakers and related wiring required for ANSI A17.1 compliance shall be provided by the electrical contractor (see power riser for more details).
   5. Security/Access Control. Provide control relays to all lock power supplies as required per code.
   6. Dry pipe/deluge sprinkler system release valve control circuits and supervision contacts shall be provided by the dry pipe/deluge sprinkler system control equipment.
   7. Carbon dioxide systems status monitoring.
   8. Area of refuge systems status monitoring.
   9. BDA DAS systems monitoring. Provide for each police and fire department BDA DAS.
      a. Signal booster trouble
      b. Normal AC power
      c. Failure of battery charger
      d. Low battery capacity

e. Antenna malfunction

10. Emergency generator status monitoring. Provide for each generator.
    a. Generator trouble
    b. Running indication
    c. Low fuel
    d. Phase reversal
    e. Loss of phase

B. Installing dedicated outgoing RJ-31X telephone lines (2) shall be the responsibility of the Installing Electrical Contractor. Establishment of central station monitoring account shall be the responsibility of the fire alarm equipment vendor.

C. Secure permits and approvals prior to installation.

D. Prior to commencement and after completion of work notify Authorities Having Jurisdiction.

E. Submit letter of approval for installation before requesting acceptance of system.

1.5 APPLICABLE CODES AND STANDARDS

A. All equipment shall be UL listed for its intended use and conform to the latest UL Standards.

B. Underwriters Laboratories Inc.: The system and all components shall be listed by Underwriters Laboratories Inc. for use in fire protective signaling system under the following standards as applicable:

1. UL 864/UOJZ, APOU Control Units for Fire Protective Signaling Systems.
2. UL 268 Smoke Detectors for Fire Protective Signaling Systems.
3. UL 268A Smoke Detectors for Duct Applications.
4. UL 217 Smoke Detectors Single Station.
5. UL 521 Heat Detectors for Fire Protective Signaling Systems.
6. UL 228 Door Holders for Fire Protective Signaling Systems.
7. UL 464 Audible Signaling Appliances.
8. UL 1638 Visual Signaling Appliances.
9. UL 38 Manually Activated Signaling Boxes.
10. UL 346 Waterflow Indicators for Fire Protective Signaling Systems.
11. UL 1971 Standard for Signaling Devices for the Hearing Impaired
12. UL 1481 Power Supplies for Fire Protective Signaling Systems.
13. UL 1711 Amplifiers for Fire Protective Signaling Systems.
14. UUKL The Fire Alarm system shall be UUKL for Smoke Control.

C. This installation shall comply with:

1. Americans with Disabilities Act (ADA)
2. National Electric Code, Article 760.
3. National Fire Protection Association Standards: NFPA72
4. Local and State Building Codes and the Local Authorities Having Jurisdiction.
5. International Standards Organization (ISO): ISO-9001

1.6 SUBMITTALS

A. Provide list of all types of equipment and components provided. This shall be incorporated as part of a Table of Contents, which will also indicate the manufacturer's part number, the

description of the part, and the part number of the manufacturer's product datasheet on which the information can be found.

B. Provide description of operation of the system (Sequence of Operation), similar to that provided in Part 2 of this Section of the Specifications, to include any and all exceptions, variances or substitutions listed at the time of bid. Any such exceptions, variances or substitutions which were not listed at the time of bid and are identified in the submittal, shall be grounds for immediate disapproval without comment. The sequence of operation shall be project specific and shall provide individual sequences for every type of alarm, supervisory, or trouble condition, which may occur as part of normal or off-normal system use.

C. Provide manufacturer's original printed product data, catalog cuts and description of any special installation procedures. Photocopied and/or illegible product data sheets shall not be acceptable. All product datasheets shall be highlighted or stamped with arrows to indicate the specific components being submitted for approval.

D. Provide manufacturer's installation instruction manual for specified system.

E. Provide samples of various items when requested.

F. Provide copy of State License to perform such work.

G. Provide copies of NICET Level IV Fire Alarm certifications for a minimum of two (2) technicians assigned to this project.

H. Provide shop drawings as follows:

1. Coversheet with project name, address and drawing index.
2. General notes drawing with peripheral device backbox size information, part numbers, device mounting height information, and the names, addresses, point of contact, and telephone numbers of all contract project team members.
3. Device riser diagram that individually depicts all control panels, annunciators, addressable devices, and notification appliances. Shall include a specific, proposed point descriptor above each addressable device. Shall include a specific, discrete point address that shall correspond to addresses depicted on the device layout floor plans. Drawing shall provide wire specifications, and wire tags shown on all conductors depicted on the riser diagram. All circuits shall have designations that shall correspond with those require on the control panel and floor plan drawings. End-of-line resistors (and values) shall be depicted.
4. Control panel termination drawing(s). Shall depict internal component placement and all internal and field termination points. Drawing shall provide a detail indicating where conduit penetrations shall be made, so as to avoid conflicts with internally mounted batteries. For each additional data gathering panel, a separate control panel drawing shall be provided, which clearly indicated the designation, service and location of the control enclosure. End-of-line resistors (and values) shall be depicted.
5. Device typical wiring diagram drawing(s) shall be provided which depict all system components, and their respective field wiring termination points. Wire type, gauge, and jacket shall also be indicated. When an addressable module is used in multiple configurations for monitoring or controlling various types of equipment, different device typical diagrams shall be provided. End-of-line resistors (and values) shall be depicted.
6. Device layout floor plans shall be created for every area served by the fire alarm system. CAD Files (AutoCAD latest version) shall be provided by the consulting engineer for the use of the fire alarm system equipment vendor in the preparation of the floor plans. Floor plans shall indicate accurate locations for all control and peripheral devices. Drawings

shall be NO LESS THAN 1/8 INCH SCALE. All addressable devices shall be depicted with a discrete address which corresponds with that indicated on the Riser Diagram. All notification appliances shall also be provided with a circuit address which corresponds to that depicted on the Riser Diagram. If individual floors need to be segmented to accommodate the 1/8" scale requirements, KEY PLANS and BREAK-LINES shall be provided on the plans in an orderly and professional manner. End-of-line resistors (and values) shall be depicted.

7. Contained in the title block of each drawing shall be symbol legends with device counts, wire tag legends, circuit schedules for all addressable and notification appliance circuits, the project name/address, and a drawing description which corresponds to that indicated in the drawing index on the coversheet drawing. A section of each drawing title block shall be reserved for revision numbers and notes. The initial submission shall be Revision 0, with Revision A, B, or C as project modifications require.

I. Battery calculations shall be provided on a per power supply/charger basis. These calculations shall clearly indicate the quantity of devices, the device part numbers, the supervisory current draw, the alarm current draw, totals for all categories, and the calculated battery requirements (which reflect a 20% DEGRADE, for 24-Hour supervisory, 15-minute alarm operation). Battery calculations shall also reflect all control panel component, remote annunciator, and auxiliary relay current draws. Failure to provide these calculations shall be grounds for the complete rejection of the submittal package.

J. Table of contents, product data sheets, sequences of operation, battery calculations, installation instructions, licenses, NICET certifications and B-Size (blackline) reduced shop drawings shall be provided by the fire alarm vendor as part of a single, spiral bound submittal book. The submittal book shall have laminated covers indicating the project address, project number, system type, and contractor. The book shall consist of labeled dividers, and shall not exceed 9 ½" in width, and 11 ½" in height. No less than three (3) sets of submittal booklets shall be provided to the consulting engineer for review and comment. Additional copies may be required at no additional cost to the project.

K. Scale drawing sets shall be submitted along with the submittal booklets. These drawings may be either D-Size or E-Size Blueline drawings and of a sufficient resolution to be completely read. Sets shall be bound and folded so that is does not take up more than 100 square inches of space. No less than three (3) sets of scale drawing sets shall be provided to the consulting engineer for review and comment. Additional copies may be required at no additional cost to the project.

L. Seismic Qualification Certificates: For fire-alarm control unit, accessories, and components, from manufacturer.

M. Field quality-control reports.

N. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 include the following:

1. Comply with the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
2. Provide "Record of Completion Documents" according to NFPA 72 article "Permanent Records" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter.
3. Record copy of site-specific software.
4. Provide "Maintenance, Inspection and Testing Records" according to NFPA 72 article of the same name and include the following:

a. Frequency of testing of installed components.
b. Frequency of inspection of installed components.
c. Requirements and recommendations related to results of maintenance.
d. Manufacturer's user training manuals.

5. Manufacturer's required maintenance related to system warranty requirements.
6. Abbreviated operating instructions for mounting at fire-alarm control unit.
7. Retain subparagraph below if Project contains water-based sprinkler or standpipe systems.
8. Copy of NFPA 25.

O. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.7 AS-BUILT DRAWINGS

A. At the conclusion of the project, the Contractor shall provide “as built” drawings. The “as built” drawings shall be a continuation of the Contractors shop drawings as modified, augmented, and reviewed during the installation, check out and acceptance phases of the project. All drawings shall be fully dimensioned and prepared in DWG format using the latest version of AutoCAD.

B. The as-built drawings shall incorporate all updated system riser diagrams prepared in DWG format using the latest version of AutoCAD.

C. The as-built drawings shall show point-to-point wiring of all devices as installed in the field.

1.8 OPERATION AND MAINTANANCE MANUALS

A. Manuals

1. At the conclusion of the project, the contractor shall provide copies of the manuals as described herein. Each manual’s contents shall be identified on the cover. The manual shall include names, addresses, and telephone numbers of each system integrator installing equipment and systems and the nearest service representatives for each item of equipment for each system. The manuals shall have a table of contents and labeled sections. The manuals shall include all modifications made during installation, checkout, and acceptance. The manuals shall contain the following:
2. Operators Manual
   a. The operator’s manual shall fully explain all procedures and instructions for the operation of the system including:
      1) Computers and peripherals
      2) System start up and shut down procedures
      3) Use of system, command, and applications software
      4) Recovery and restart procedures
      5) Graphic alarm presentation
      6) Use of report generator and generation of reports
      7) Data entry
      8) Operator commands
      9) Alarm messages and reprinting formats

10) System access requirements

3. Maintenance Manual
   a. The maintenance manual shall include descriptions of maintenance for all equipment including inspection, periodic preventive maintenance, fault diagnosis, and repair or replacement of defective components.

1.9 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level III technician. Provide certification with the submittal package.

C. System Engineering and Shop Drawings Qualifications: System engineering and shop drawings shall be by performed by a NICET fire-alarm Level IV technician. Provide certification with the submittal package.

D. Source Limitations for Fire-Alarm System and Components: Obtain fire-alarm system from single source from single manufacturer.

E. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.10 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.

B. Technical Support: Beginning with Substantial Completion, provide software support for two years.

C. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.

1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

1.11 WARRANTY

A. Comply with Section 260001.

B. The Electrical Trade Contractor shall warranty that all materials furnished shall be free from defects of material for a period of one year from the date of Substantial Completion.

C. Manufacturer’s Warranty

1. The manufacturer shall guarantee that the fire alarm panel technology and firmware is the latest available and shall be supported for at least 10 years.
2. The manufacturer shall guarantee that the system components shall be available for at least 10 years.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Approved Manufacturers

1. NOTIFIER; a Honeywell company – NFS2-3030.
2. Edwards Systems Technology – EST4.
3. Johnson Controls Inc. - 4100ES.
4. Or approved equal.

B. The basis of design system shall be NOTIFIER; a Honeywell company – NFS2-3030 with Emergency Voice Evacuation System.

2.2 CIRCUITING GUIDELINES

A. Each addressable analog loop shall be circuited so device loading is not to exceed 80% of loop capacity in order to leave for space for future devices. The loop shall have Class A operation.

1. Class A circuits must meet the performance requirements that “allow all connected devices to operate during a single open or a non-simultaneous single ground fault on any circuit conductor.”
2. Class A circuits must be installed so that the outgoing and return conductors, exiting from and returning to the control unit, respectively, are routed separately. The outgoing and return (redundant) circuit conductors must also not be run in the same cable assembly (i.e., multi-conductor cable), enclosure or raceway.
3. Circuit survivability:
   a. Circuit survivability shall apply to speaker circuit riser cables. All circuits necessary for the operation of the notification appliances shall be protected until they enter the evacuation signaling zone that they serve. Any of the following shall be considered to meet the requirements of this subsection:
      1) A two-hour fire rated MI cable.
      2) A two-hour fire rated cable system (electrical circuit protective system).
      3) A two-hour fire rated enclosure.
      4) Performance alternatives approved by the authority having jurisdiction.
   b. The recommended minimum separation to prevent physical damage to riser circuits is 305 mm (1 ft.) where the cable is installed vertically and 1.22 m (4 ft.) where the cable is installed horizontally. The important factor in the requirement is to prevent physical damage to the fire alarm circuits. The requirement also means that the raceways or cables cannot cross over each other.

B. Where it is necessary to interface conventional initiating devices provide intelligent input modules to supervise Class A zone wiring.

C. Each of the following types of devices or equipment shall be provided with supervised circuits as shown on the drawings but shall be typically as follows:

1. Sprinkler Valve Supervisory Switches: Provide one (1) supervisory module circuit for each sprinkler valve supervisory switch.
2. When waterflow and tamper switches exist at the same location, provide one (1) dual input addressable module. When odd numbers of devices exist at a single location, provide additional single input addressable modules.

D. Each of the following types of alarm notification appliances shall be circuited as shown on the drawings but shall be typically as follows:

1. Audible Signals: Provide sufficient spare capacity to assure that the addition of five (5) audible devices can be supported without the need for addition control components (power supplies, signal circuit modules, amplifiers, batteries, etc.)
2. Visual Signals Provide sufficient spare capacity to assure that the addition of three (3) visual devices can be supported without the need for addition control components (power supplies, signal circuit modules, batteries, etc.)

E. Each of the following types of remote equipment associated with the fire alarm system shall be provided with a form 'C' control relay contact as shown on the drawings, but shall be typically as follows:

1. HVAC Fan Systems: Provide one (1) shutdown control relay contact for each HVAC fan system.
2. HVAC Supply Fans: Provide one (1) shutdown control relay contact for each HVAC supply fan.
3. HVAC Return Fans: Provide one (1) shutdown control relay contact for each HVAC return fan.

F. Provide a dedicated 24VDC circuit to feed all auxiliary relays required for inductive loads. Circuits shall be supervised via an end-of-line relay and addressable input module. Auxiliary relays shall not derive their power from the starter or load being controlled.

G. Each control or data gathering panel shall have a dedicated 20Amp-120VAC feed. This feed shall come from an emergency or lighting circuit breaker panel and shall have a locked circuit breaker. Earth grounds shall also terminate to the same circuit breaker panel from each respective control panel.

2.3 FIRE ALARM SYSTEM SEQUENCE OF OPERATION

A. The system shall identify any off normal condition and log each condition into the system database as an event.

1. The system shall automatically display on the control panel Liquid Crystal Display the first event of the highest priority by type. The priorities and types shall be alarm, supervisory, trouble, and monitor.
2. The system shall have a Queue operation and shall not require event acknowledgment by the system operator. The system shall have a labeled color-coded indicator for each type of event; alarm - red, supervisory - yellow, trouble - yellow, monitor - yellow. When an unseen event exists for a given type, the indicator shall be lit.
3. For each event, the display shall include the current time, the total number of events, the type of event, the time the event occurred and up to a 42-character custom user description.
4. The user shall be able to review each event by simply selecting scrolling keys (up-down) for each event type.
5. New alarm, supervisory, or trouble events shall sound a silencing audible signal at the control panel.

B. Operation of any alarm initiating device shall automatically:

1. Update the control/display as described above (A.1.)

2. Sound all audible speaker appliances with a prerecorded message. Audible devices shall have the ability to be silenced.
3. Activate all strobe appliances throughout the facility. All strobe appliances shall be synchronized with each other in any location with two or more devices in a common field of view. Visual devices shall be non-silenced unless the system is successfully reset.
4. Operate control relay contacts to shut down all HVAC units serving the floor of alarm initiation.
5. Operate control relay contacts to return all elevators that serve the floor of alarm initiation to the ground floor. If the alarm originates from the ground floor, operate control circuits contacts to return all elevators to the floor above or to a level as directed by the local fire department.
6. Operate control relay contacts to release all magnetically held smoke doors throughout the building.
7. Visually annunciate the individual point of alarm on all remote annunciator panels. The visual indication shall remain on until the alarm condition is reset to normal.
8. Transmit an alarm condition, via the integral central station communicator, to central station/Local Fire Department (as required by the AHJ).

C. Elevator smoke and heat detector sequences shall comply with the ANSI A17.1 requirement for main/alternate floor recalls.

D. Activation of a sprinkler supervisory initiating device shall:

1. Update the control/display as described above.
2. Transmit a supervisory condition, via the integral central station communicator, to central station/Local Fire Department (as required by the AHJ).
3. Visually annunciate the individual point of alarm on all remote annunciator panels. The visual indication shall remain on until the alarm condition is reset to normal.

E. The entire fire alarm system wiring shall be electrically supervised to automatically detect and report trouble conditions to the fire alarm control panel. Any opens, grounds or disarrangement of system wiring and shorts across alarm signaling wiring shall automatically:

1. Update the control/display as described above.
2. Transmit a trouble condition, via the integral central station communicator, to central station/Local Fire Department (as required by the AHJ).
3. Visually and audibly annunciate a general trouble condition, on the remote annunciator panels. The visual indication shall remain on until the trouble condition is repaired.

F. Purge / Smoke Control

1. The panel shall be UUKL listed specifically for smoke control operation to allow the smoke purge control to be housed in the FACP cabinet (if approved by the Local Authority). The smoke control switches shall be located behind a locked glass door.

2.4 FIRE SAFETY FUNCTIONS

A. Emergency Elevator Functions

1. Elevator Recall and Emergency Service shall be conducted In accordance with NFPA 72. ANSI/ASME A17.1 and applicable code.
2. In addition to the alarm sequence described, the activation of automatic initiating devices located within elevator lobbies, or elevator machine rooms shall initiate the appropriate

emergency elevator functions and report the presence of smoke and heat to the building Fire Command Center.

3. Recall: Each elevator cab shall be captured separately and recalled to the main egress level. If the alarm originated on the main egress level, the elevators shall be recalled to the designated alternate level. Note: Passenger elevator shall recall upon designated recall devices only; Fire Service Access Elevators (FSAE) shall be subject to recall upon any building alarm.
4. Fire Warning Indicator: The activation of any automatic detector within an elevator machine room shall flash the fire hat indicator in each associated elevator cab.
5. Provide smoke and heat annunciation at the Fire Command Center during Phase 2 Firefighter's Emergency Override Operation of any FSAE in accordance with applicable Code and NFPA 72 requirements.

B. HVAC Override:

1. Provide supervised output signals to initiate shutdown of Air Handling Units or fans upon activation of associated in-duct or area smoke detectors as shown on the Contract Documents. Signals shall consist of a programmable output with dedicated multi-voltage power relay selected, listed and rated for the application.
2. Provide addressable monitor modules to supervise the run status of each fan or AHU, and control associated Fire/Smoke Damper control functions where required.
3. Sequencing and control of dampers and related equipment shall be closely coordinated with mechanical trades, to include shutdown of fans and timed closure of associated dampers. Coordinate all work with Division 23. The Electrical Contractor and Fire Alarm system supplier shall coordinate sequencing and safeties, and the necessary number of signals with the EMS Contractor and Mechanical Contractor.
4. All signals and wiring shall be supervised and installed in accordance in accordance with NFPA 72, NFPA 90A and applicable code.

C. Firefighter's Smoke Control Panel (FSCP):

1. General
    a. Provide FSCP with manual override H-O-A switches and status indicating lights for all air distribution systems that will be subject to manual override from the main fire alarm control panel (FACP)/fire command center (FCC) location.
    b. Each switch shall have 3-positions to support manual On ("hand"), Off and Automatic control functions. Each switch shall have a green "On" and a red "Off* status indicators corresponding to their respective switch positions that indicate proof of functional status.
    c. Each switch shall send override signals to the associated equipment and receive end-status feedback from the controlled system to illuminate each status indicator.
    d. Provide signals for each required H-O-A switch position and status indication to corresponding Energy Management System (EMS/BMS/BAS)) equipment interface termination points.
    e. UL category UUKL listed components and modules shall provide Alarm, Manual Stop and Manual Start signals and status feedback between the fire alarm System and each controlled system or device. Signals shall be wired directly to the controlled equipment.
    f. Coordinate all work with Division 23. The Electrical Contractor and Fire Alarm system supplier shall coordinate the number of required H-O-A switches with the EMS Contractor and Mechanical Contractor.
    g. All LED indicators shall be programmed to report status feedback of the controlled equipment via from a dry contact signals generated from the equipment controller.

h. All signals and wiring shall be supervised and installed in accordance with NFPA 72, NFPA 90A, 92A/B and applicable code.

2. Fire Alarm Interface & LED Designation:
   a. The fire alarm control panel (FACP) shall fully monitor and enable the stair tower pressurization system. The fire alarm control panel in conjunction with the associated graphic panel shall monitor and present real time status display of all components and incorporate fire fighter override control. Each damper and fan operator associated with the stair tower pressurization system shall have four (4) status indicating lights identified as follows:
      1) ON (Open for damper) - Green LED
      2) OFF (Closed for Damper) - Red LED
      3) NORMAL - White LED
      4) FAULT - Yellow LED
      5) Stair Tower Smoke Detector Alarm - Blue LED
      6) Power On - Green LED
   b. The intake and relief damper shall be hard wired to the fan enable such that the FACP will command the fan VFD on and the VFD programming will be configured to command the intake and relief dampers to open, and once the intake damper is proved open via end switch shall allow the VFD to enable.
      1) The respective LED shall light when the associated damper or fan is in its commanded position whether it be via automatic mode or manual override.
      2) The normal LED shall be programmed to be lit whenever the respective fan and damper is in its commanded state while in automatic mode. If the manual override key is placed in manual position the normal LED shall be off as confirmed with the local AHJ.
      3) The fault LED shall be programmed to be lit whenever any of the connected devices is not in its commanded position whether it be in the automatic mode or manual override. It shall also light if the fan disconnect or VFD disconnect power to each fan detects and Off position (i.e. disconnect turned off).
      4) The stair tower smoke detector alarm blue LED's shall be programmed to be lit if either of the respective fans has been automatically commanded off due to alarm of the stair tower smoke detectors.
   c. Sequence Of Operation:
      1) The stair tower pressurization systems shall be enabled and disabled by the interface to the fire alarm system (FACP). The FACP shall be directly wired to enable/disable and monitor the system. The EMS contractor shall program the VFD and furnish and wire the respective intake and relief dampers to the VFD controller. Once enabled, the EMS system shall control the fan speed as specified herein.
      2) Upon building fire alarm activation of the system, the FACP shall send an enable command to the SPF fan VFD. The VFD shall programmed and wired to command the intake and relief dampers open and prove the intake dampers is open prior to allowing the VFD to start the fan. Fans shall vary speed to maintain stair tower pressure with respect to outdoors to no less than 0.1 "w.c and no more than 0.35" w.c. with a current control setpoint of 0.15" w.c. System shall continue to run until disabled and reset at the fire fighters control panel. A run report shall be saved and logged by the FACP. Note: This pressure setpoint shall be adjusted during balancing to ensure proper operation of door operators is maintained with the lowest allowable being 0.1" w.c.
      3) The pressure relief damper shall open fully when the system is enabled. The EMS shall monitor the damper open and closed position and report an alarm

if the damper is not in the proper position (i.e. not open when system is enabled and not closed if system is disabled). A counterweighted backdraft damper in line with relief damper shall be adjusted to maintain a static pressure in the stair tower of no greater than 0.25" w.c. Note: This relief damper pressure shall be adjusted during balancing to ensure proper operation of door operators is maintained.

4) To enable the Manual Override feature for the stair tower fans a key operated switch must be toggled from Auto Mode to Manual Override mode.
5) If the duct smoke detectors located in the main supply duct near the top floor of each stair tower detect smoke and go into alarm the respective stair tower pressurization fan shall be disabled however the intake damper shall remain open to allow the shaft to vent smoke. A blue indicator light shall turn on at the graphic panel indicating which fan is disabled due to this condition.
6) Every week at a preset time the system shall activate and run for 60 seconds or as long as required to establish normal operation. Upon completion of weekly test and proof of normal operation, the printer shall print out the weekly test report. If normal operation is not established within 120 seconds during the weekly test the fans shall be disabled, dampers shall close and the FACP shall report a trouble alarm and the printer shall print out the weekly test report identifying the fault items.
7) A lamp test switch shall be programmed to light all LED indicator lights on the panel when pushed.

d. HVAC/EMS Interface
   1) Signals and wiring between the Fire Alarm and HVAC/Building Automation control systems and equipment shall operate as stated herein, be closely coordinated with Division 23 and be installed in accordance with all applicable codes and standards.
   2) Interconnections between systems will take place at both field-located addressable modules and an EMS Interface Cabinet.
      a) Fire Alarm control signal outputs (to EMS) corresponding to each floor subject to post-event smoke removal (12 points total).
      b) Status feedback (inputs from EMS) corresponding to each post-event smoke removal zone (12 points total).
      c) Fire Alarm control signal (outputs to EMS) to indicate a general alarm on a per-floor basis (12 points total).
   3) Signals, Sequencing and Overrides shall be as follows:
      a) Provide discrete outputs from the Fire Alarm System to the EMS system corresponding to each automatic initiating zone, and the activation each duct-mounted smoke detector.
      b) The fire alarm system shall monitor interconnected ventilation systems' equipment status to ensure operation is coordinated with related trades.
      c) Whenever an air handling unit is manually or automatically commanded off, the fire alarm system shall close all associated smoke dampers.
      d) The fire alarm system shall supervise a "request to start" signal from designated HVAC equipment, and shall operate as follows:
      e) Upon receipt of a request to start signal, the fire alarm system shall command associated smoke or fire/smoke dampers at the shaft penetrations to the open.
      f) Any failure or mismatch of the intended state shall be reported as a system trouble condition.
   4) Wiring from the Fire Alarm output modules to the BAS equipment controller will be provided by the BAS contractor to allow for the following operation:

a) When the H-O-A switch is in the "AUTO" position, the controlled equipment shall operate as directed by the BAS system.
b) When the H-O-A switch is in the "HAND" position, a signal shall be sent to the BAS equipment controller to bypass control of the selected equipment and turn the controlled equipment on. The controlled equipment shall continue to operate until the H-O-A switch is restored to the "AUTOMATIC" or "OFF" position.
c) When the H-O-A switch is in the "OFF" position, a signal shall be sent to the BAS equipment controller to bypass control of the selected equipment and turn the controlled equipment off. The controlled equipment shall remain in the off condition until the H-O-A switch is restored to the "AUTOMATIC" or "HAND" position.
d) Manual override signals shall be subject to all required safety functions.

5) Initial automatic and manual control signals will be generated and sent to the controlled equipment by the Fire Alarm System. Actual control sequencing shall be conducted by the BAS System to ensure proper system operation.
6) HVAC air handling units or fans serving as supply, return or exhaust fans shall have separate H-O-A switches for each device.
7) HVAC air handling units or fans consisting of multiple fans, in parallel, in a common unit, shall have one H-O-A switch that is intended to control both fans simultaneously.
8) Status signals between the Firefighter's Override Switches or Smoke Control Panel and the BAS system shall be provided for all equipment that is subject to manual override. In each instance, the BAS system shall confirm the actual equipment or sequence status (on, off, fail) and provide corresponding signals to illuminate the appropriate LED at each H-O-A switch.
9) The Contractor shall coordinate with the Mechanical, BAS and Fire Alarm system suppliers to ensure the proper rating (amperage and voltage) and contact types are provided between systems to accomplish the above.
10) Coordinate life safety, smoke control, fire alarm and fire protection zoning to ensure proper signals and sequencing are affected.
11) Wiring to all smoke control systems including but not limited to fans, dampers, and end switches shall be in conduit. Identify smoke control wiring systems with labels at all junction boxes, access points, above accessible ceilings, and every 20' of conduit run. All wiring to dedicated smoke control systems - regardless of voltage - shall utilize 2 hour fire-rated cable systems (MI or equivalent).
12) Activation of H-O-A switches, smoke exhaust or smoke control systems shall generate a system Trouble condition as described herein.
13) All life safety fan power to smoke control equipment must be monitored ahead of the motor controller. The disconnect switch position must also be Supervised and transmitted as a Supervisory signal to the BAS and Fire Alarm System and Supervising Station.
14) All input and output signals used to control the spread of smoke shall comply with IBC, NFPA 72, 92A and 92B, and be Listed to UL 864 category UUKL requirements.
15) Dedicated Smoke Control Equipment shall be preprogrammed to conduct automatic weekly self-testing, with printed reports and electronic archiving of event history logging.

D. Fire/Smoke Damper Interface

1. Coordinate all work with Division 23 and provide smoke detection and supervised output signals to initiate control of each Fire/Smoke or Smoke Damper (F/SDs) shown on the Contract Documents. Signals shall consist of a programmable output with dedicated multi-voltage power relay selected, listed and rated for the application.
2. When the detectors used for smoke damper operation require minimum air velocity to operate, the dampers shall be closed when the associated fan(s) are shut down to comply with IBC requirements.
    a. Sequencing and control of dampers and associated air distribution equipment shall be closely coordinated with Division 23 trades. This shall include supervision of fan operation and corresponding shaft F/S damper position, whereby shaft F/S dampers shall be closed whenever associated fans are Off and be commanded to the open position whenever associated fans are On or requested to start.

E. Dedicated Smoke Control Functions

1. All equipment that serves dedicated smoke control functions shall be controlled directly by the Fire Alarm System. Equipment shall include the Stairwell Pressurization Systems.
2. Provide signals to the controlled equipment to initiate the required sequencing in accordance with applicable code and according to the required Sequence of Operation for related systems.
3. Control signals and status monitoring of dedicated smoke control equipment will be subject to the requirements for Firefighter's Override functions stated herein.

F. Security System Interface

1. In addition to the alarm condition operation described above, the system shall send event signals, via auxiliary dry contact closure corresponding to each floor or evacuation zone to the building security system.
2. Provide override switch to activate signals to unlock secure egress doors, disable door operators or bypass any other special locking arrangements - subject to coordination with the Owner's security requirements and applicable Code.

G. Audio/Visual and Lighting Control System Interface

1. In the event of an alarm condition, the system shall send signals to the audio/visual systems and lighting systems in the evacuation area to override sound systems and bring lighting up to full illumination.

2.5 SUPPORT FOR INSTALLER AND OWNER MAINTENANCE

A. Provide a coded one-man walk test feature. Allow audible or silent testing. Signal alarms and troubles during test. Allow receipt of alarms and programmed operations for alarms from areas not under test.

B. Provide internal system diagnostics and maintenance user interface controls to display/report the power, communication, and general status of specific panel components, detectors, and modules.

C. Provide loop controller diagnostics to identify common alarm, trouble, ground fault, Class A fault, and map faults. Map faults include wire changes, device type changes by location, device additions/deletions and conventional open, short, and ground conditions. Ground faults on the circuit wiring of remote module shall be identified by device address.

D. Allow the user to display/report the condition of addressable analog detectors. Include device address, device type, percent obscuration, and maintenance indicator. The maintenance indicator shall provide the user with a measure of contamination of a device upon which cleaning decisions can confidently be made.

E. Allow the user to report history for alarm, supervisory, monitor, trouble, smoke verification, watchdog, and restore activity. Include Facility Name, Licensee, Project Program Compilation date, Compiler Version, Project Revision Number, and the time and date of the History Report.

F. Allow the user to disable/enable devices, zones, actions, timers and sequences. Protect the disable function with a password.

G. Allow the user to activate/restore outputs, actions, sequences, and simulate detector smoke levels.

H. Allow the service user to enter time and date, reconfigure an external port for download programming, initiate auto programming and change passwords.

2.6 UL LISTED AND APPROVED EQUIPMENT

A. Fire Alarm Control Panel Requirements: The fire alarm control panel or panels and all system devices (Speaker-strobes, strobes, pull stations, smoke, and heat detectors, etc. shall be all under one label “UL listed and approved” for the use of fire alarm systems in this area of the United States of America. The operating controls shall be located behind locked door with viewing window. All control modules shall be labeled, and all zone locations shall be identified.

B. System Controllers: The main controller 3-CPU shall be supervised, site programmable, and of modular design supporting up to 125 detectors and 125 remote modules per addressable Signaling line Circuit (SLC). The CPU shall support up to 10 SLC's per panel for a total system capacity of 2500 Intelligent Addressable points.

C. Network Configurations: The system shall be designed for enhanced survivability and support multiple media connections including twisted pair copper, fiber, and Category 6A interfaces. Configurations for panel-to-panel communications shall support Class A, Class B, Class X and Class N topologies. The cabinets shall be steel.

D. The Main Controller Module shall control and monitor all local or remote peripherals. The panel touch screen LCD display shall be a minimum of 5.7 inches in size and support a minimum of 256K colors. Each display shall support a minimum of 8 events simultaneously without the need to scroll or make manual selections at the display. If configured as a network, each system shall display each point in the system and shall also support touch screen display annunciators. Remote annunciators shall also display each point in the system and be sized with the same number of characters as in the main FACP display.

E. The panel shall have an interface module for remote site monitoring. The module shall have a dialer (alarm communicator transmitter (DACT)) module to transmit alarm, supervisory and trouble signals to a Central Monitoring Station (CMS). The DACT shall support dual telephones lines, Contact I.D. communications, and configured for dual tone multi-frequency (DTMF) or pulse modes. It shall be possible to delay AC power failure reports, auto test call, and be site programmable. The dialer shall be capable of transmitting every individual alarm condition to the central station.

F. The system shall have built-in automatic system programming to automatically address and map all system devices attached to the main controller. A minimum default single stage alarm system operation shall be supported with alarm silence, event silence, drill, lamp test, and reset common controls.

G. Advanced Windows-based System Definition Utility with Program Version Reporting to document any and all changes made during system start-up or system commissioning shall be used to maintain site specific programming. Time and Date Stamps of all modifications made to the program must be included to allow full retention of all previous program version data. It shall support programming of any input point to any output point. The system shall support the use of Bar Code readers to assist custom programming functions. It shall allow authorized customization of fundamental system operations using initiating events to start actions, timers, sequences and logical algorithms. The system program shall meet the requirements of this project, current codes and standards, and satisfy the local Authority Having Jurisdiction.

H. The system shall support distributed processor intelligent detectors with the following operational attributes; integral multiple differential sensors, automatic device mapping, electronic addressing, environmental compensation, pre-alarm, dirty detector identification, automatic day/night sensitivity adjustment, normal/alarm LEDs, relay bases, sounder bases and isolator bases.

I. The system shall use full digital communications to supervise all addressable loop devices for placement, correct location, and operation. It shall allow swapping of “same type” devices without the need of addressing and impose the “location” parameters on replacement device. It shall initiate and maintain a trouble if a device is added to a loop and clear the trouble when the new device is mapped and defined into the system.

J. Each controller shall contain a RS232 printer/programming port for programming locally via an IBM PC. When operational, each controller shall support a printer through the RS232 port and be capable of message routing.

K. Single stage operation shall be provided.

L. The system shall have a UL Listed Detector Sensitivity test feature, which will be a function of the smoke detectors and performed automatically every 4 hours.

M. The system shall support 100% of all remote devices in alarm and provide support for a 100% compliment of detector isolator bases.

N. All panel modules shall be supervised for placement and return trouble if damaged or removed.

O. Provide emergency audio as part of the fire alarm control. The emergency audio shall contain a paging microphone, pre-recorded messages and zoned amplifiers capable of delivering multi-channel audio messages. The system shall support a minimum of 100 audio channels. Transmission of audio shall be over the same data network cabling as the fire panel data. Each panel shall store digitally up to 750 minutes of pre-recorded audio message files without the need to add additional memory storage devices. These messages shall be automatically played in various areas of a facility under program control. The system shall have the capacity to store up to 250 individual audio messages. An audio channel shall support up to 250 individual messages. Each panel shall support simultaneous play back of seven (7) different message channels in addition to a live page message. Systems that cause signaling devices to go silent while performing any signaling functions will not be accepted. The system shall support repeat counts of audio messages and stacking of audio messages in a FIFO configuration. Each FACP containing an audio amplifier or audio source connection shall contain its locally required pre-

recorded messaging onboard. Should a fire AND a control network system failure occur, the programmed pre-recorded messages shall be played from the locally stored data. Sending pre-recorded messages across a network or external panel interconnection shall not be considered equal. Should local pre-recorded audio be unavailable, the local amplifiers shall provide an integral backup 1 KHz temporal tone generator which shall operate in the event primary audio signals are lost and the amplifier is instructed to broadcast alarm information. The amplifier shall support an alert pattern distinct from the evacuation temporal tone pattern.

P. Audio Amplifiers: Every floor/level shall have a dedicated amplifier(s) assigned to do audio on that floor/level. Amplifier configurations that distribute audio signals to multiple floors/levels from one amplifier will not be acceptable. Each audio power amplifier shall have integral audio signal de-multiplexers, allowing the amplifier to select any one of eight digitized audio channels. The channel selection shall be directed by the system software. Each amplifier output shall include a dedicated, supervised 25/70 Vrms speaker circuit which is suitable for connection of emergency speaker appliances. Each amplifier shall also include a notification appliance circuit rated at 24Vdc @ 3.5A for connection of visible (strobe) appliances. This circuit shall be fully programmable, and it shall be possible to define the circuit for the support of audible, visible, or ancillary devices. Standby Audio amplifiers shall be provided that automatically sense the failure of a primary amplifier, and automatically program themselves to select and de-multiplex the same audio information channel of the failed primary amplifier, and fully replace the function of the failed amplifier. In the event of a total loss of audio data communications, all amplifiers will default to the local “EVAC” tone generator channel. If the local panel has an alarm condition, then all amplifiers will sound the EVAC signal on their connected speaker circuits. In the event of a loss of the fully digitized, multiplexed audio riser, the audio amplifiers shall automatically default to an internally generated alarm tone which shall be operated at a 3-3-3 temporal pattern. Audio amplifiers shall automatically detect a short circuit condition on the connected speaker circuit wiring and shall inhibit itself from driving into that short circuit condition.

Q. Network Control Display User Interface:

1. A Network Control Display (NCD) shall be provided to display all intelligent system points. The NCD shall be capable of displaying information for all events on a fully utilized network of at least 300,000 points. Network display devices that are capable of displaying only a subset of network points shall not be suitable substitutes.
2. The NCD screen shall have a resolution of 1024x600 with touch capability, including audible and visible feedback, backlit by a long life, solid-state LCD. It shall also include a full QWERTY-style keypad on the color, touchscreen display. Additionally, the network display shall have the ability to scroll events by type (i.e. Fire Alarm, Supervisory Alarm, Trouble, etc.) using the touchscreen.
3. The NCD shall have the ability to display up to 3,000 events in order of priority and time of occurrence. Counters shall be provided to indicate the total number of events by type.
4. The NCD shall mount in any of the network node fire alarm control panels. Optionally, the network display may mount in a backbox designed for this use. The NCD shall connect to the network over either a wire or fiber interface.
5. The NCD shall have an event history buffer capable of storing 10,000 events in non-volatile memory.
6. The NCD shall include touchscreen buttons for system-wide control of Acknowledge, Signal Silence, System Reset, Drill, and local Lamp Test.
7. The NCD shall include indication on the touchscreen of Fire Alarm, Trouble, Supervisory, Signals Silenced, Disabled Points, and other (non-fire) events. The NCD will also include LEDs to indicate primary power status and any off-normal event.
8. The NCD shall include a Master username and password and up to 49 additional usernames and passwords. Each password shall be up to 16 alpha-numeric characters

in length. The Master password shall be authorized to access the programming and alter status menus. Each User password may have different levels of authorization. Each user access shall be saved in history.

9. The NCD shall allow control (on/off) of outputs and enable/disable of network points.
10. The NCD shall support a Windows® based programming utility. This utility shall allow the user to create an NCD database, upload/download an NCD database, and download an upgrade to the NCD executive. To ensure program validity, this utility shall check stored databases for errors. A compare function shall be included to identify differences between databases. The program utility shall have a secure connection to the NCD.
11. The NCD shall incorporate display conditioning to prevent image persistence and screen distortion.
12. The NCD shall provide the ability to disable the touchscreen for a predetermined period to allow for cleaning. The time period for this mode shall be programable.
13. The NCD shall be capable of event-based filtering, allowing all active events to be filtered by type for easier viewing.
14. The NCD shall utilize color coded user guidance to indicate the order of operation during an event.
15. Provide NCD at each fire alarm node and annunciator.

R. Power Supplies: The power supply shall be a high efficiency switch mode type with line monitoring to automatically switch to batteries for power failure or brown out conditions. The automatic battery charger shall have low battery discharge protection. The power supply shall provide internal power and 24 Vdc at 7.0A continuous for notification appliance circuits. The power supply shall be capable of providing 7A to output circuits for a maximum period of 100 ms. All outputs shall be power limited. The battery shall be sized to support the system for 24 hours of supervisory and trouble signal current plus general alarm for 15 minutes.

S. Auxiliary power supplies shall be a high efficiency switch mode type with line monitoring to automatically switch to batteries for power failure or brown out conditions. The automatic battery charger shall have low battery discharge protection. The power supply shall provide internal power and 24 Vdc at 7.0A continuous for notification appliance circuits. The power supply shall be capable of providing 7A to output circuits for a maximum period of 100 ms. All outputs shall be power limited. The battery shall be sized to support the system for 24 hours of supervisory and trouble signal current plus general alarm for 15 minutes.

2.7 ONE WAY EMERGENCY VOICE COMMUNICATIONS

A. One-way voice paging shall be accomplished through a push-to-talk paging microphone located at the Main Fire Alarm Control Panel and designated remote panels. Provide audio control switches at each location to selectively activate or bypass signals to individual areas on a selective or All Call basis.

B. The system shall support an auxiliary audio paging input(s) from the facility general paging and telephone systems. These inputs will be assigned a low priority and support general purpose paging without causing unwarranted trouble conditions. Additional input and output signals, and prioritization of signals may be required to meet the Owner's approved Mass Notification requirements and emergency response plans and procedures.

C. The microphone shall be a dynamic communication type with a frequency range of 200 Hz to 4,000 Hz and shall be equipped with 3'-0" retractable coiled cord. An LED shall be provided to indicate the microphone push-to-talk button has been pressed and speaker circuits are ready for transmission.

D. Manual Voice Paging

1. The system shall be configured to provide selective manual voice paging and initiation of prerecorded messages to individual or selected groups of evacuation signaling zones.
2. Upon activation of any speaker manual control switch, two (2) seconds of tone (different from the Alert Tone or Evacuation tone) shall sound throughout the selected area, indicating an impending voice message will occur.
3. Once a paging area is selected, the operator shall be able to broadcast a prerecorded message or make announcements via the push-to-talk paging microphone to the selected area.
4. The system shall support multi-channel audio operation, whereby the act of manual paging or broadcast to a selected building area will not disrupt any signaling taking place in other building areas.
5. The system will provide manual emergency paging on a selective basis to each evacuation signaling zone and an All-Call basis throughout the building.
6. The system shall support constant supervision of speaker circuits to allow general non-alarm paging without causing an off-normal (Trouble) condition.

E. Provide area paging selector switches with LED indicators for each floor level and evacuation zone as follows:

1. LEVEL 0
2. LEVEL 1
3. LEVEL 2
4. LEVEL 3
5. LEVEL 4
6. LEVEL 5
7. ELEVATOR 1
8. ELEVATOR 1
9. STAIR A1
10. STAIR B1
11. STAIR D1
12. STAIR D2
13. STAIR C1
14. STAIR C2
15. STAIR E2
16. ALL CALL

F. Speaker circuits serving each building area or evacuation zone shall be configured and programmed to broadcast a distinct audio channel.

2.8 ONYXWORKS® FIRE SYSTEMS COMMAND INTERFACE

A. Furnish and install ONYXWorks® in the Fire Command Center with 22” touch screen monitor. Provide programing and setup for a fully functional system.

B. The ONYXWorks® is an intuitive graphical display that allows personnel to rapidly pinpoint, investigate, and respond to alarm events with minimal operator training.

C. Features

1. Operates on Microsoft Windows 10 (64 bit, Enterprise)
2. Monitor options: 22" and 42" Standard and Touchscreen

3. Supports up to 200 intelligent gateways, with 200 nodes per gateway
4. Maximum Remote Users: 50
5. Point Capacity: 250,000
6. History File Capacity: 2.5 Million Records
7. Supports the following additional languages: Spanish, French, Korean, Portuguese, Hebrew, and Chinese (Traditional and Simplified)
8. Compatible with standard, high-speed NOTI-FIRE-NET™, and Ethernet-based networks
9. NOTI*FIRE»NET™ gateway redundancy for network survivability

D. User Interface

1. Customizable interface provides flexibility to display information as desired.
2. Supports dual monitors
3. Dynamically generated floor plan overview provides point of reference when using the zoom function
4. Global Zoom Level for devices {0 - 100%), definable by the administrator
5. Device information, including point address and description, can be quickly accessed through icon left-click function
6. Navigational tree, icons and configurable areas provide easy access to system floor plans

E. Event Notification and Response

1. Graphic and text display of all off-normal events.
2. Six states can be visually represented for each input device: Normal, Trouble, Fire Alarm, Pre-Alarm (detectors). Disabled, and Security.
3. Automatic screen navigation (configurable) to the device in alarm, based on event priority.
4. Multimedia (text, audio, video and bitmaps) can be linked to any device, providing instructions to operators for event response.
5. Operator log with response tracking.
6. ONYX-NOTIFY feature provides e-mail and text notification for off-normal events.
7. NOTIFY-IP feature supports Voice-Over-IP paging for mass notification.
8. Real-time message override capability to LED-Signs on NOTI-FIRE-NET™.

F. System Setup

1. Graphic Editing mode allows on-site or off-site system setup.
2. Import building floor plan CAD drawings (as a .DXF, .WMF. .BMP, JPG, or .GIF).
3. Customizable device icon and colors to visually represent each event type.
4. AutoPlace feature automatically places devices in their proper location (.DXF's).
5. User defined icons can be globally defined (.PNG, .BMP. .WMF, JPG. and .GIF formats).

G. Secure Access

1. System Administrator-definable user profiles provide strict levels of access.
2. Monitoring and Control profiles delineate defined operator accounts.
3. Operator Login/Logout/Change Password feature allows only authorized personnel to access the system.
4. Logs in history of any operator changes in the workstation.

H. Operations

1. Macros provide customizable programming to simplify repetitive tasks (disable/enable, de-activate/activate).
2. Individual device control and system information through icon right-click function.
3. History Manager: Filterable history reporting serves as a valuable maintenance and diagnostic tool to identify patterns.
4. Test Monitoring function enables unobtrusive testing of selected points, eliminating nuisance alarms at the workstation.

I. System Maintenance

1. Backup capability for screen, member, and history databases.
2. Obtain software version numbers for network panels (ONYX® Series fire panels).
3. Upload/Download databases to NOTIFIER ONYX series panels and perform panel upgrades (ONYX Series only) over the network using VeriFire Tools.

J. Standards and Codes

1. Comply with the following UL Standards and NFPA 72 Fire Alarm Systems requirements:
2. UL 864 (Fire)
3. UL 864 UUKL (Firefighter Smoke Control Station)
4. UL 294 (Access Control)
5. UL 1076 (Burglary)
6. UL 2017 (General Purpose Signaling)
7. UL 2572 (Mass Notification)
8. CAN/ULC S527
9. CAN/ULC S559

2.9 ONYX FIRSTVISION™ INTERACTIVE FIREFIGHTERS' DISPLAY

A. Furnish and install two (2) ONYX FirstVision™ Interactive Firefighters' Display (Graphical Command Center) as shown on the drawings. Provide programing and setup for a fully functional system.

B. The display is a wayfinding navigational tool for firefighters and other emergency responders. The touch screen interface graphically displays critical information on the origin and spread of a fire, allowing firefighters to quickly locate and extinguish it. Crucial information is easy to access with a spatial, graphical depiction of the location of activated detectors and detector sequence of activation for one or multiple buildings. It displays a summary of building floor plans with detailed information about the building. Details can include locations for all fire alarm devices; water supplies; evacuation routes; access routes; chemical and structural hazards in the building; and shutoffs for gas, power, and HVAC.

C. Features

1. 22" LCD touchscreen.
2. Interlaces with ONYX® Series panels or NOTI-FIRE-NET (version 5.0 or higher) through the NFN Gateway over Ethernet.
3. Compatible with standard and High Speed NOTI-FIRE-NET™.
4. Supports multiple gateways tor large networks and campuses.

D. User Interface

1. Large intuitive display shows building floor plans in a campus footprint with respective active fire alarm devices, water supplies, evacuation routes, access routes, gas. power and HVAC shutoffs, and chemical and structural hazards in the building.
2. Detailed information for active devices or critical building icons on the floor plan.
3. Easy access to building, emergency contacts, site plan, and alarm event information.
4. Able to print screenshots.
5. Materials Safety Datasheet (MSDS) attachment.
6. User download of event log file.

E. Event Notification

1. Graphic and text event notification of fire, supervisory, security, and medical events.
2. Fast automatic navigation to floors and locations of the emergency events.
3. Priority based event list display.
4. First alarm display to identify where the emergency started.
5. Time sequence display of activated detectors to track smoke progression.
6. Configurable sound notification with silence selection.
7. Configurable to unlock door based on events.

F. System Setup

1. Shared configuration tool with ONYXWorks can easily import building floor plan CAD drawings (as a .dxf, .wmf, .bmp, or .jpg file) and VeriFire® Tools databases.
2. Standard icon library indicates fire alarm and critical building devices.
3. Ethernet and USB ports available for transferring screen database information.

G. Listings and Approvals

1. These listings and approvals apply to ONYX FirstVision"".
   a. UL/ULC Listed: S5697
   b. MEA: 286-07-E
   c. CSFM: 7300-1525:0103

2.10 ANNUNCIATORS

A. Furnish and install two (2) annunciators with Network Control Display (NCD) and One-way Emergency Voice Communications as indicated on the drawings. Both the NCD and the emergency voice communications microphone and controls shall be housed within the same enclosure – no exceptions.

B. Furnish and install one (1) annunciator with Network Control Display (NCD) in the administration area as shown on the drawings.

2.11 COMPONENTS

A. Intelligent Devices — General: Each remote device shall have a microprocessor with non-volatile memory to support its functionality and serviceability. Each device shall store as required for its functionality the following data: device serial number, device address, device type, personality code, date of manufacture, hours in use, time and date of last alarm, amount of environmental compensation left/used, last maintenance date, job/project number, current detector sensitivity values, diagnostic information (trouble codes) and algorithms required to process sensor data and perform communications with the loop controller. Each device shall be capable of electronic addressing, either automatically or application programmed assigned, to

support physical/electrical mapping and supervision by location. Setting a device's address by physical means shall not be necessary.

B. Intelligent Detectors — General: The System Intelligent Detectors shall be capable of full digital communications using both broadcast and polling protocol. Each detector shall be capable of performing independent fire detection algorithms. The fire detection algorithm shall measure sensor signal dimensions, time patterns and combine different fire parameters to increase reliability and distinguish real fire conditions from unwanted deceptive nuisance alarms. Signal patterns that are not typical of fires shall be eliminated by digital filters. Devices not capable of combining different fire parameters or employing digital filters shall not be acceptable. Each detector shall have an integral microprocessor capable of making alarm decisions based on fire parameter information stored in the detector head. Distributed intelligence shall improve response time by decreasing the data flow between detector and analog loop controller. Detectors not capable of making independent alarm decisions shall not be acceptable. Maximum total analog loop response time for detectors changing state shall be 0.5 seconds. Each detector shall have a separate means of displaying communication and alarm status. A green LED shall flash to confirm communication with the analog loop controller. A red LED shall flash to display alarm status. The detector shall be capable of identifying up to 32 diagnostic codes. This information shall be available for system maintenance. The diagnostic code shall be stored at the detector. Each smoke detector shall be capable of transmitting pre-alarm and alarm signals in addition to the normal, trouble and need cleaning information. It shall be possible to program control panel activity to each level. Each smoke detector may be individually programmed to operate at any one of five (5) sensitivity settings. Each detector microprocessor shall contain an environmental compensation algorithm that identifies and sets ambient "Environmental Thresholds" approximately six times an hour. The microprocessor shall continually monitor the environmental impact of temperature, humidity, other contaminates as well as detector aging. The process shall employ digital compensation to adapt the detector to both 24-hour long term and 4-hour short-term environmental changes. The microprocessor shall monitor the environmental compensation value and alert the system operator when the detector approaches 80% and 100% of the allowable environmental compensation value. Differential sensing algorithms shall maintain a constant differential between selected detector sensitivity and the "learned" base line sensitivity. The base line sensitivity information shall be updated and permanently stored at the detector approximately once every hour. The intelligent analog detectors shall be suitable for mounting on any Signature Series detector mounting base.

2.12 FIXED TEMPERATURE / RATE OF RISE HEAT DETECTOR

A. Provide intelligent combination fixed temperature/rate-of-rise heat detectors at the locations shown on the drawings. The heat detector shall have a low mass thermistor heat sensor and operate at a fixed temperature and at a temperature rate-of-rise. It shall continually monitor the temperature of the air in its surroundings to minimize thermal lag to the time required to process an alarm. The integral microprocessor shall determine if an alarm condition exists and initiate an alarm based on the analysis of the data. Systems using central intelligence for alarm decisions shall not be acceptable. The intelligent heat detector shall have a nominal fixed temperature alarm point rating of 135 deg. F (57 deg. C) and a rate-of-rise alarm point of 15 deg. F (9 deg. C) per minute. The heat detector shall be rated for ceiling installation at a minimum of 70 ft. (21.3m) centers and be suitable for wall mount applications. Where shown on the project plans, include combination Heat and Carbon Monoxide (CO) detector. The combination Heat and CO device shall report separately to the control panel where a heat condition is considered a fire alarm and a CO condition is a supervisory alarm with separate and unique evacuation sequence.

2.13 COMBINATION HEAT AND CO DETECTOR

A. At the locations shown on the project plans, include combination Heat and Carbon Monoxide (CO) detector. The combination Heat and CO device shall report separately to the control panel where a heat condition is considered a fire alarm and a CO condition is a supervisory alarm with separate and unique evacuation sequence.

2.14 PHOTOELECTRIC SMOKE DETECTOR

A. Provide intelligent multi-criteria UL268 7th edition photoelectric smoke detectors model at the locations shown on the drawings. The optical detector shall be listed as a multi criteria detector without the use of other sensing elements, and the use of fixed end of life sensing components is not acceptable. Each optical smoke detector shall be capable of rejecting nuisance sources and detect smoke in the full life safety window of 0.5% to 4.36% obscuration/foot. Must be listed to UL268 7th edition. Detectors that must operate in a special application mode that cannot achieve the full 0.5% to 4.36% life safety window shall not be considered equal. The analog photoelectric detector shall utilize a light scattering type photoelectric smoke sensor to sense changes in air samples from its surroundings. The integral microprocessor shall dynamically examine values from the sensor and initiate an alarm based on the analysis of data. Systems using central intelligence for alarm decisions shall not be acceptable. The detector shall continually monitor any changes in sensitivity due to the environmental effects of dirt, smoke, temperature, aging and humidity. The information shall be stored in the integral processor and transferred to the analog loop controller for retrieval using a laptop PC or the Program/Service Tool. The photo detector shall be rated for ceiling installation at a minimum of 30 ft. (9.1m) centers and be suitable for wall mount applications. The photoelectric smoke detector shall be suitable for direct insertion into air ducts up to 3 ft. (0.91m) high and 3 ft. (0.91m) wide with air velocities up to 5,000 ft./min. (0-25.39 m/sec) without requiring specific duct detector housings or supply tubes. The percent smoke obscuration per foot alarm set point shall be field selectable to any of five sensitivity settings ranging from 1.0% to 3.5%. The photo detector shall be suitable for operation in the following environment: Temperature: 32 deg. F to 120 deg. F (0 deg. C to 49 deg. C), Humidity: 0-93% RH, non-condensing, Elevation: no limit.

2.15 ADDRESSABLE MULTI-CRITERIA SMOKE WITH CARBON MONOVIDE (CO) DETECTOR

A. Provide intelligent multi-criteria UL268 7th edition photoelectric smoke detectors with carbon monoxide (CO) detectors at the locations shown on the drawings. The combination smoke and CO detector shall provide two independent signals (smoke & CO) to the control panel for programming system responses. When mounted in a sounder base, the detector shall be capable of initiating a temporal 3-3-3 when smoke is detected or temporal 4-4-4-4 when CO is detected. Units installed in sleeping or potential sleeping units shall be capable of generating a low frequency 520hz signal. Detectors that transmit a common signal to the control panel for both smoke and CO alarms shall not be considered as equals. The detector shall be listed under standards UL-268 and UL-2075. Each smoke detector shall be individually programmable to operate at any one of five (5) sensitivity settings. The detector shall also store pre-alarm and alternate pre-alarm sensitivity settings. Pre alarm sensitivity values shall be configurable in 5% increments of the alarm and alternate alarm sensitivity settings respectively. The detector shall be able to differentiate between a long-term drift above the pre alarm threshold and fast rise above the threshold. The detector shall monitor the sensitivity of the smoke sensor. If the sensitivity shifts outside the UL limits, a trouble signal shall be sent to the panel. It shall be possible to automatically change the sensitivity of individual intelligent addressable smoke detectors for day and night (alternate) periods. Each detector shall utilize an environmental compensation algorithm that shall automatically adjust for background environmental conditions

such as dust, temperature, and pressure. The detector shall provide a maintenance alert signal when 80% (dirty) of the available compensation range has been used. The detector shall provide a dirty fault signal when 100% or greater compensation has been used. The electro-chemical CO sensor shall generate a CO alarm in compliance with UL-2034 requirements. When the sensor approaches the end of its useful life, it shall transmit a maintenance condition to the control panel, indicating the CO sensor board replacement is required. Only when the sensor is no longer operational shall a trouble condition be sent to the control panel. Sensors that transmit a common trouble indication for both sensor end-of-life and other causes of detector trouble shall not be considered as equal. Performing a “sensitivity” check from the panel shall report the approximate number months of CO sensor life remaining. Placing the CO detector in test mode shall facilitate the use of direct injection of small quantities of CO to check detector functionality.

2.16 ADDRESSABLE CARBON MONOXIDE (CO) DETECTOR

A. Provide addressable carbon monoxide (CO) detectors at the locations shown on the drawings. The CO detector shall provide a signal to the control panel for programming system responses. When mounted in a sounder base, the detector shall be capable of initiating a temporal 4-4-4-4 signal when CO is detected. The detector shall be listed under standard UL-2075. The electro-chemical CO sensor shall generate a CO alarm in compliance with UL-2034 requirements. The sensor shall have a nominal six-year life. Performing a “sensitivity” check from the panel shall report the approximate number months of sensor life remaining. When the sensor approaches the end of its useful life, it shall transmit a maintenance condition to the control panel, indicating the CO sensor board replacement is required. Only when the sensor is no longer operational shall a trouble condition be sent to the control panel. Detectors that transmit a common trouble indication for both sensor end-of-life and other causes of detector trouble shall not be considered as equal.

2.17 STANDARD DETECTOR MOUNTING BASES

A. Provide standard detector mounting bases suitable for mounting on North American 1-gang, 3½” or 4” octagon box and 4” square box. The base shall, contain no electronics, support all Signature Series detector types and have the following minimum requirements: Removal of the respective detector shall not affect communications with other detectors, Terminal connections shall be made on the room side of the base, bases that must be removed to gain access to the terminals shall not be acceptable. The base shall be capable of supporting one (1) Remote Alarm LED Indicator.

2.18 AUDIBLE DETECTOR MOUNTING BASE

A. Provide audible/sounder bases suitable for mounting on North American 1-gang, 3½” or 4” octagon box and 4” square box. The sounder base shall be capable of two tones, Temporal 3 for a fire condition and Temporal 4 for a Carbon monoxide condition. The tones shall be fully programmable and synchronize the sound with other sounder bases. The system shall be UL2017 listed for dual signaling for this purpose. The base shall be capable of supporting one (1) Remote Alarm LED Indicator.

2.19 REMOTE ALARM INDICATORS

A. Provide remote alarm indicators and permanently attached placard for all detectors that are installed behind locked doors and/or as indicated on the drawings.

B. The location of the detector and the area protected by the detector shall be prominently indicated at the remote alarm indicator by a permanently attached placard.

C. Remote alarm or supervisory indicators shall be installed in an accessible location and shall be clearly labeled to indicate both their function and any device or equipment associated with each detector.

2.20 NATURAL GAS DETECTOR

A. Basis of Design Macurco GD-2B low voltage electronic detector of combustible, heating type gases, calibrated for methane (natural gas) and propane (LP) gas.

B. Features

1. Designed to meet UL Standard 2075 for the standard for safety for gas and vapor detectors and sensors
2. Sensitivity tested based on UL 1484 standard for residential gas detectors
3. Detects heating gases: propane (LP), natural gas (methane)
4. SPST alarm and trouble relays
5. Self-restoring or latching
6. 10-year solid-state electronic sensor: no maintenance or recalibration
7. Temperature compensated
8. Supervised sensor

C. Specifications

1. Size: 3-1/8 x 5-1/8 x 1-3/4 inch (7.94 x 13.02 x 4.4 cm)
2. Shipping weight: 0.54 pound
3. Voltage: 9-32VDC, 12-24VAC
4. Current (non-alarm): 40 ma @ 12 VDC, 20 ma @ 24 VDC, 34 ma @ 12 VAC, 17 ma @ 24 VAC
5. Current (in alarm): 56 ma @ 12 VDC, 28 ma @ 24 VDC, 46 ma @ 12 VAC, 23 ma @ 24 VAC
6. Color: white
7. Sensor maintenance: not required
8. Alarm relay rating: SPST, 100ma, 40VDC
9. Trouble relay: SPST, 100ma, 40VDC
10. Operating temperature range: 32° to 120° F
11. Alarm set point: per UL 1484 (25% LEL)

2.21 DUCT DETECTOR

A. Provide model low profile intelligent addressable duct smoke detector as indicated on the project plans. Provide for variations in duct air velocity between 100 and 4,000 feet per minute and include a wide sensitivity range of .79 to 2.46%/ft. Obscuration. Include one Form-C shut down relay rated 2.0 amps @ 30 Vdc and also include slave high contact relays if required. Provide an air exhaust tube and an air sampling inlet tube that extends into the duct air stream up to ten feet. The addressable DUCT housing shall be suitable for extreme environments,

including a temperature range of –20 to 158 degrees F and offer a harsh environment gasket option. Provide Remote Alarm LED Indicators and remote test station as indicated on the project plans.

B. Exterior Enclosure: A NEMA 4X weatherproof duct housing enclosure shall be provided for the circulation of conditioned air around the addressable duct sensor housing to maintain the sensor housing at its rated temperature range when the duct detector is mounted on the exterior of the building. The housing shall be UL Listed to Standard 268A.

C. Sequence of operation:

1. Upon sensing smoke, the duct smoke detector shall stop the fan(s) and de-energize controls through a direct circuit normally closed (NC) interlock contacts.
2. A set of normally open (NO) contacts will close, to signal the fire alarm system to initiate a supervisory alarm. The fire alarm system will report the alarm to the fire department.
3. A second set of NO contacts shall close and signal the building management system (BMS).

D. Smoke Damper Actuation

1. The smoke damper shall close upon actuation of a listed smoke detector or detectors installed in accordance with one of the following methods, as applicable:
   a. Where a smoke damper is installed within a duct, provide a smoke detector installed in the duct within 5 feet (1524 mm) of the damper with no air outlets or inlets between the detector and the damper. The detector shall be listed for the air velocity, temperature and humidity anticipated at the point where it is installed. Other than in mechanical smoke control systems, dampers shall be closed upon fan shutdown where local smoke detectors require a minimum velocity to operate.
   b. Where a smoke damper is installed above smoke barrier doors in a smoke barrier, provide a spot-type detector listed for releasing service installed on either side of the smoke barrier door opening.
   c. Where a smoke damper is installed within an air transfer opening in a wall, provide a spot-type detector listed for releasing service installed within 5 feet (1524 mm) horizontally of the damper.
   d. Where a smoke damper is installed in a corridor wall or ceiling, the damper shall be controlled by the smoke detection system installed in the corridor.
   e. Where a total-coverage smoke detector system is provided within areas served by a heating, ventilation, and air-conditioning (HVAC) system, smoke dampers shall be controlled by the smoke detection system.

2.22 BEAM DETECTORS

A. Projected Beam Detector – Single End: The projected beam type smoke detector shall be a 4-wire 12/24 Vdc device monitored by the Fire Alarm control panel through a two circuit monitor module (one zone for alarm and one for trouble). The unit shall be listed to UL 268 and shall consist of an integrated transmitter and receiver. The beam detector shall operate between a range of 15 and 160 feet or 160 and 330 feet (contractor shall determine distance to select appropriate model). It shall feature automatic gain control, which will compensate for gradual signal deterioration due to dirt accumulation on the lenses. The unit shall include a wall mounting bracket. Testing shall be carried out using a calibrated test filter. Furnish and install a remotely installed key-operated test station to test the detector without direct access to it.

2.23 INTELLIGENT MODULES

A. General: It shall be possible to address each Intelligent Signature Series module without the use of DIP or rotary switches. Devices using DIP switches for addressing shall not be acceptable. The personality of multifunction modules shall be programmable at site to suit conditions and may be changed at any time using a personality code downloaded from the Analog Loop Controller. Modules requiring EPROM, PROM, ROM changes or DIP switch and/or jumper changes shall not be acceptable. The modules shall have a minimum of 2 diagnostic LEDs mounted behind a finished cover plate. A green LED shall flash to confirm communication with the loop controller. A red LED shall flash to display alarm status. The module shall be capable of storing up to 24 diagnostic codes which can be retrieved for troubleshooting assistance. Input and output circuit wiring shall be supervised for open and ground faults. The module shall be suitable for operation in the following environment: Temperature: 32 deg. F to 120 deg. F, Humidity: 0-93% RH, non-condensing.

B. Single Input Module, (Waterflow Detectors, Tamper Switches etc.): Provide intelligent single input modules at the locations of devices shown on the drawings. The Single Input Module shall provide one (1) supervised Class B input circuit capable of a minimum of 4 personalities, each with a distinct operation. The module shall be suitable for mounting on North American 2 ½" (64mm) deep 1-gang boxes and 1 ½" (38mm) deep 4" square boxes with 1-gang covers. The single input module shall support the following circuit types: Normally-Open Alarm Latching (Manual Stations, Heat Detectors, etc.), Normally-Open Alarm Delayed Latching (Waterflow Switches), Normally-Open Active Non-Latching (Monitor, Fans, Dampers, Doors, etc.), Normally-Open Active Latching (Supervisory, Tamper Switches).

C. Isolation Module: Provide isolation modules to subdivide each signaling line circuit into groups of not more than 25 addressable devices between adjacent isolation modules.

D. Dual Input Module:: Provide intelligent dual input modules at the locations of devices shown on the drawings. The Dual Input Module shall provide two (2) supervised Class B input circuits each capable of a minimum of 4 personalities, each with a distinct operation. The module shall be suitable for mounting on North American 2 ½" deep 1-gang boxes and 1 ½" (38mm) deep 4" square boxes with 1-gang covers. The dual input module shall support the following circuit types: Normally-Open Alarm Latching (Manual Stations, Heat Detectors, etc.), Normally-Open Alarm Delayed Latching (Waterflow Switches), Normally-Open Active Non-Latching (Monitor, Fans, Dampers, Doors, etc.), Normally-Open Active Latching (Supervisory, Tamper Switches).

E. Single Input Signal Module: Provide intelligent single input signal modules at locations of devices shown on the drawings. The Single Input (Single Riser Select) Signal Module shall provide one (1) supervised Class B output circuit capable of a minimum of 2 personalities, each with a distinct operation. When selected as a telephone power selector, the module shall be capable of generating its own "ring tone". The module shall be suitable for mounting on North American 2 ½" (64mm) deep 2-gang boxes and 1 ½" (38mm) deep 4" square boxes with 2-gang covers, or European 100mm square boxes. The single input signal module shall support the following operations: Audible/Visible Signal Power Selector (Polarized 24 Vdc @ 2A).

F. Control Relay Module (2A or less): Provide intelligent control relay modules at locations of devices shown on the drawings. The Control Relay Module shall provide one form "R" dry relay contact rated at 2 amps @ 24 Vdc to control external appliances or equipment shutdown. The control relay shall be rated for pilot duty and releasing systems. The position of the relay contact shall be confirmed by the system firmware. The control relay module shall be suitable for mounting on North American 2 ½" (64mm) deep 1-gang boxes and 1 ½" deep 4" square boxes with 1-gang covers.

G. Control Relay Module (high current): Provide high current intelligent control relay modules for applications where external loads exceed 2.0A. Any external load exceeding 2.0A shall require an addressable high current relay for switching. Addressable relay shall support 120/240 VAC 7.0A and 24VDC 6A. No pilot relays shall be acceptable for connection to the addressable relay. All addressable relay functions shall be incorporated into the addressable device and shall not require the connection and wiring of separate relays. Addressable relay shall have 2 separate form C contacts, accepting 12 to 18AWG wiring from two sources. The control module shall be suitable for mounting on North American double gang or standard 4' square boxes.

2.24 INTELLIGENT MANUAL PULL STATIONS

A. General: It shall be possible to address each Signature Series fire alarm pull station without the use of DIP or rotary switches. Devices using DIP switches for addressing shall not be acceptable. The manual stations shall have a minimum of 2 diagnostic LEDs mounted on their integral, factory assembled single or two stage input module. A green LED shall flash to confirm communication with the loop controller. A red LED shall flash to display alarm status. The station shall be capable of storing up to 24 diagnostic codes that can be retrieved for troubleshooting assistance. Input circuit wiring shall be supervised for open and ground faults. The fire alarm pull station shall be suitable for operation in the following environment: Temperature: 32F to 120F, Humidity: 0-93% RH, non-condensing.

B. Manual Pull Station: Provide intelligent single action, single stage fire alarm stations at locations shown on the drawings. The fire alarm station shall be of metal construction with an internal toggle switch. Provide a locked test feature. Finish the station in red with silver "PULL IN CASE OF FIRE" English lettering. The manual station shall be suitable for mounting on North American 2 ½" deep 1-gang boxes and 1 ½" deep 4" square boxes with 1-gang covers.

C. Parking or outdoor area Pull Stations shall be NEMA 4X rated for outdoor use and key operated. Matching weatherproof back box to be included. Addressable monitor module for monitoring of pull station to be installed in environmentally controlled area.

D. STI Stopper II Lexan Guards: Manual pull stations that are provided with STI Stopper II Lexan guards shall include non-audible alarms as required on the plans. They shall be surface or flush mounting, as required for each individual device. Stopper Covers shall be installed at all pull station locations unless otherwise noted.

2.25 NOTIFICATION APPLIANCES

A. General: All appliances shall be UL Listed for Fire Protective Service. All strobe appliances or combination appliances with strobes shall be capable of providing the "Equivalent Facilitation" which is allowed under the Americans with Disabilities Act accessibility guidelines (ADA(AG)), and shall be UL 1971, and ULC S526 Listed. All appliances shall be of the same manufacturer as the Fire Alarm Control Panel specified to ensure absolute compatibility between the appliances and the control panels, and to ensure that the application of the appliances are done in accordance with the single manufacturers' instructions. Any appliances that do not meet the above requirements and are submitted for use must show written proof of their compatibility for the purpose intended. Such proof shall be in the form of documentation from the control panel manufacturer clearly stating that the control equipment (as submitted) is 100% compatible with the submitted Notification Appliances.

B. Strobes: Provide ceiling/wall mounted strobes at the locations shown on the drawings. All visual devices are to be calculated at the highest candela setting of 110cd. In the event that strobe candela coverage for a given area needs to be increased, any additional current draw

will already be calculated and available on the circuit. Strobes shall provide synchronized flash outputs. Strobe output shall be field selectable as indicated on the drawings in one of the following intensity levels; 15cd, 30cd, 75cd or 110cd. Candela setting switch shall be accessible while device is mounted on wall. Strobes shall mount in a standard North American 1-gang, 2-gang, 4-inch octagon, and 4-inch square electrical boxes, and protrude less than 1.5” from the finished wall. To ensure a clean installation a room side wiring plate shall connect to the backbox for easy snap in of the device. The wiring plate shall have a circuit integrity bar that can be removed to ensure all wiring can be field inspected before device installation. For surface mount applications, provide a matching back box provided by the manufacturer, as directed in the field.

C. Speakers: Provide ceiling/wall mounted speakers with a 4” cone at locations shown on the drawings. Speaker must provide a frequency response between 400 – 4,000 HZ, a STI index of at least .81, and must be UL tested and approved. The rear of the speaker shall be completely sealed protecting the cone during and after installation. Screw terminals shall be provided for wiring and the speaker housings shall be red and include "FIRE" labeling. Speakers shall be provided for use with 70 or 25V systems and shall provide power taps at 1/4w, 1/2w, 1w, and 2w. Speakers shall provide UL confirmed 87 dBA sound output at 2w with an STI rating of .81. All speakers mounted in sleeping, or potential sleeping rooms, shall be UL approved and capable of delivering a 520 HZ square wave signal. Speakers shall mount in a North American 4” electrical box with extension ring using the 2 screws provided with ring. For easier installation a room side wiring plate shall connect to the backbox for easy snap in. The wiring plate shall have a circuit integrity bar that can be removed to ensure all wiring can be field inspected before device installation. It must not be necessary to completely remove the screws to facilitate mounting.

D. Speaker/Strobes: Provide ceiling/ wall mounted speaker/strobes at the locations shown on the drawings. All visual devices are to be calculated at the highest candela setting of 110cd. If strobe candela coverage for a given area needs to be increased, any additional current draw will already be calculated and available on the circuit. Speaker must provide a frequency response between 400 – 4,000 HZ, a STI index of at least .81, and must be UL tested and approved. The rear of the speaker shall be completely sealed protecting the cone during and after installation. Screw terminals shall be provided for wiring and the speaker housings shall be red and include "FIRE" labeling. Speakers shall have a switch to select either 70 or 25V options. Speakers not capable of use at either voltage will not be accepted. Devices shall provide power taps at 1/4w, 1/2w, 1w, and 2w. Speakers shall provide UL confirmed 87 dBA sound output at 2w with an STI rating of no less than .81. All units shall install to a room side wiring plate, for convenient installation and troubleshooting. All speakers mounted in sleeping, or potential sleeping rooms, shall be UL approved and capable of delivering a 520 HZ square wave signal. Speakers shall mount in a North American 4” electrical box. Strobes shall provide synchronized flash outputs. Strobe output shall be field selectable as indicated on the drawings in one of the following intensity levels; 15cd, 30cd, 75cd or 110cd. Candela setting switch shall be accessible while device is mounted on wall.

E. Outdoor area notification devices shall all be weatherproof and listed for the application along with weatherproof back box. Speakers shall be provided for use with 70V systems and shall provide power taps at 1/4w, 1/2w, 1w, and 2w. Speaker/strobes shall provide UL confirmed 90 dBA sound output at 2w. Strobes shall provide 15, 29, 70 & 87 candela synchronized flash outputs. The strobe shall have lens markings oriented for wall mounting.

2.26 MULTI-VOLTAGE CONTROL RELAYS

A. Provide remote control relays connected to supervised ancillary circuits for control of fans, dampers, door releases, etc. Relay contact ratings shall be DPDT and rated for 10 amperes at

115 Vac. A single relay may be energized from a voltage source of 24 Vdc, 24 Vac, 115 Vac, or 230 Vac. A red LED shall indicate the relay is energized. A metal enclosure shall be provided.

2.27 ELECTROMAGNETIC DOOR HOLDERS

A. General: Electromagnetic door holders submitted for use must have written proof of their compatibility for the purposes intended. Such proof shall be in the form of documentation from all manufacturers that clearly states that their equipment (as submitted) is 100% compatible with each other for the purposes intended.

B. Provide flush, semi-flush or surface wall mounted electromagnetic door holder/releases rated at 24 Vac/dc at the locations shown on the drawings. Finish shall be brushed zinc.

2.28 KNOX BOX

A. Furnish and install where shown on the drawings.

B. The Knox box shall be flush mounted Knox Box model 4400 (Verify with Fire Department) Series with tamper switch.

C. Features: Box and lock are UL® Listed. Weather resistant door gasket. Hinged door allows single-handed operation. Colors: Black, Dark Bronze or Aluminum. Verify with the Architect. Coordinate mounting (surface or recessed) and color with the Architect. Provide monitor module to supervise the Knox box against tampering.

2.29 TERMINAL CABINETS

A. Furnish and install as required.

B. Coordinate color with the Architect.

C. Provide Space Age or equal.

2.30 CENTRAL STATION ALARM REPORTING

A. Furnish and install two phone lines to the fire alarm control panel in 3/4” EMT. The phone lines shall be cross connected ahead of the phone system.

B. Include the costs at a UL listed central station for the duration of the warranty period.

2.31 TEST TOOL

A. In order to expedite the installation process and ensure proper install of devices, include a manufacturer’s certified technician test tool to be supplied to the installing Contractor that will identify opens and shorts in the addressable loop. The test tool shall also indicate errors in addressing of specific devices as well as condition of devices in the loop.

2.32 RADIO MASTERBOX

A. The installation shall comply with the requirements of the Fire Department. Refer to the rules and regulations provided by the fire department.

B. All master boxes shall be radio transmitter type.

C. Master boxes shall be installed in accordance with NFPA 1221.

D. The radio master fire alarm box connected to the fire protection system must be compatible with the receiving equipment of the fire department. The Contractor shall coordinate the requirements with the fire department.

E. The master box shall be mounted on the inside of the building at the main entrance, next to the fire alarm panel or annunciator. Coordinate exact location with fire department prior to installation.

F. The Contractor shall provide all necessary connections, materials, contacts, relay cards, etc. in the existing fire alarm panel to facilitate interconnection to the masterbox.

2.33 EXTERIOR BEACON

A. Basis of design shall be Edwards Signaling 3000SD-EK Series 150,000 candle power strobe.

1. Red for fire alarm.
2. White or blue for sprinkler flow alarm (verify with fire department).

2.34 SYSTEM PRINTER

A. Provide a UL-Listed and approved event printer to document and record all system events, tests and reports.

B. Provide spare printer cartridge and printing paper.

2.35 FIRE COMMAND CENTER

A. The Fire Command Center shall be comprised of the Main Fire Alarm Control Panel (FACP) and include the following components:

1. Network Control Display.
2. LED matrix display to allow a quick analysis of the alarm condition by initiating device type and zone location as described herein. Provide discrete LED indication of related equipment such as the emergency generator, Fire Protection systems and devices, and related fire safety functions. Indicators shall be logically grouped and sequenced consistently for ease of use.
3. One and Two-way emergency voice communication equipment controls.
4. A framed graphic map of the building layout showing each floor level with building entrance and egress points, stairwells, main corridors, elevators fire pump and fire department connections clearly noted.
5. A full-size graphic drawing depicting HVAC system air flow diagrams.
6. Firefighter's Smoke Control Panel (FSCP)
7. Post-event smoke removal (purge) and air distribution systems' controls.

8. All system control switches and programming keys.
9. Status indicators and manual override or bypass switches as specified herein.
10. System event printer.
11. As-built record documents/drawings and cabinet telephone and a worktable sized to accommodate full size drawings.
12. Equipment provided by other Divisions including, elevator status panel, generator status panel, emergency lighting, wired network data connection(s) and an analog telephone with a direct outside line.
13. Control for simultaneous unlocking of all interior egress doors and floor re-entry stairwell doors.
14. In-building Radio Enhancement Systems annunciator panels.
15. Building information card including general information, classification, construction type, exit access, etc. as directed by the local authorities and IBC 911.1.6.13.

PART 3 - EXECUTION

3.1 INSTALLATION

A. The entire system shall be installed in a workmanlike manner, in accordance with approved manufacturer's wiring diagram. The contractor shall furnish all conduit, wiring, outlet boxes, junction boxes, cabinets, and similar devices necessary for the complete installation. All wiring shall be of the type recommended by the manufacturer, approved by the local Fire Department and specified with in.

B. All penetration of floor slabs and firewalls shall be sleeved (1" conduit minimum) fire stopped in accordance with all local fire codes.

C. End of Line Resistors shall be furnished as required for mounting as directed by the manufacturer. Devices containing end-of-line resistors shall be appropriately labeled. Devices should be labeled so removal of the device is not required to identify the EOL device.

D. All manual pull stations shall be mounted 48 inches above the finished floor, as measured to the handle.

E. All audio/visual devices shall be mounted 80 inches above the finished floor, as measured to the lens. Devices shall be mounted no less than 6 inches from the ceiling. All audiovisual devices shall have Lexan covers in all areas subject to mechanical damage.

F. No area smoke detectors shall be mounted within 36 inches of any HVAC supply, return air register or lighting fixture.

G. No area smoke or heat detector shall be mounted within 12 inches of any wall. All detectors shall be installed in strict accordance with NFPA 72 guidelines for such devices.

H. All device wiring shall be installed in 3/4" conduit.

I. All addressable modules shall be mounted within 36 inches of the monitored or controlled point of termination. This shall include, but is not necessarily limited to, fan shutdown, elevator recall, shunt trip, sprinkler status points, Ansul/Hood subsystems, or door release. Label all addressable modules as to their function.

J. New door holders shall derive their 24VAC/VDC power from a separate power supply housed in a dedicated, metal enclosure. The power supply shall have a 120VAC feed and is to be centrally located to serve door holders on a per floor or area basis. All existing door holders shall be connected to new FACP. E.C. shall extend all existing wiring in order to make this work. Locations and quantities of door holder power supplies shall be referenced and submitted in the submission package for approval by the Engineer.

K. All low voltage wiring terminated to the fire alarm system shall be plenum rated with no exceptions and no less than no. 18 awg. in size, and solid copper.

L. All line voltage (120vac) wiring shall be no less than no. 12 awg. in size, and solid copper. This shall include all system grounding. FACP must have a dedicated 20A circuit marked back at the power panel no exceptions.

M. All wiring shall be color-coded throughout, to National Electrical Code standards.

N. Power-limited/Non-power-limited NEC wiring standards shall be observed.

O. All junction box covers shall be painted federal safety red and labeled FIRE ALARM SYSTEM ONLY in black letters.

P. Fire alarm system wiring shall not co-mingle with any other system wiring in the facility. Conduits shall not be shared under any circumstance. Only when fire alarm wiring enters the enclosure of a monitored or controlled system will co-habitation be permitted (i.e. at fan starters or elevator controllers).

Q. Fire alarm control panel enclosures shall have engraved labels indicating, “FIRE ALARM SYSTEM”, and the areas of the building served by that panel.

R. Auxiliary relays shall be appropriately labeled to indicate “FIRE ALARM SYSTEM” and their specific function (i.e., FAN S-1 SHUTDOWN).

S. All fire alarm wiring shall be continuous and un-spliced. Terminations shall only occur at fire alarm devices or control panel enclosures under terminal screws. All other splicing methods are specifically disallowed (i.e., plastic wire nuts).

T. All fire alarm wiring shall be installed using a dedicated system of supports (i.e., bridle rings). Fire alarm wiring shall not be bundled or strapped to existing conduit, pipe, or wire in the facility.

U. All fire alarm wiring shall be sleeved when passing through any wall, using conduit sleeves (1” min.) with bushings, and fire stopped in accordance with Code.

V. The system shall be arranged to receive power from one three wire 120 Vac, 20A supply. All low voltage operation shall be provided from the fire alarm control panel.

W. All fire alarm devices shall be accessible for periodic maintenance. Should a device location indicated on the Contract Drawings not meet this requirement, it shall be the responsibility of the installing contractor to bring it, in writing, to the attention of the Project Engineer. Failure to bring such issues to the attention of the Project Engineer shall be the exclusive liability of the installing Electrical Contractor.

X. The existing fire alarm system shall remain in operation until such time that approval has been granted for its removal. The installing Electrical Contractor shall be responsible for the upkeep of the existing system until such time that it can be removed.

3.2 CIRCUITS AND PATHWAYS

A. System circuits shall be configured as follows:

1. Addressable analog SLC loops Class A.
2. Initiating Device Circuits Class A.
3. Notification Appliance Circuits Class A.
4. Network Communications Class A.
5. Annunciator Communications Class A.

B. Network Communications and vertical trunk wiring

1. All network wiring and audio risers shall be Class A, Style X circuits as defined in NFPA 72, utilizing physically separated outgoing and return loops and a minimum Level 2 survivability.
2. All circuits that serve occupant notification shall have a minimum Level 2 Survivability from their point of origin until they enter the evacuation signaling zone served in accordance with NFPA 72 and these Specifications.

C. Addressable Signaling Line Circuit (SLC)

1. Vertically-wired addressable loop SLC trunk wiring shall be configured as Class A (style X) circuits with minimum Level 2 survivability, and Level 2 survivability for circuits serving smoke control functions.
2. Horizontal SLC branch circuits shall be Class A wired circuits with a minimum of Level 1 survivability, with Level 2 survivability for circuits that serve smoke control and Phase 2 Fire Service Access Elevator (FSAE) control functions.
3. Fault Tolerance: SLC wiring shall utilize fault isolation modules so that a single wiring fault on the conductors serving one floor or evacuation signaling zone will not affect the operation of devices serving any other floor or zone. In addition, provide a minimum of one fault isolation module shall be provided for every 25 devices within a zone.

D. Audible Notification Circuits

1. Speaker Notification Appliance Circuits (NAC) shall be configured as Class A circuits, with a minimum Level 2 pathway survivability from their point of origin to the area served, and Level 1 within the evacuation signaling zone served.
2. The system shall be provided with the minimum listed speaker circuits as follows:
   a. Two (2) speaker circuits for each evacuation signaling zone or smoke compartment; whichever is greater.
   b. One (1) speaker circuit for each stairwell, configured as a vertical paging zone with Level 2 survivability (minimum) until they enter the stairwell served.
   c. One (1) speaker circuit for each elevator cab, configured as a vertical paging zone.
   d. Speaker circuits shall be individually selective by evacuation signaling zones.
3. Twisted shielded cable shall be utilized for speaker circuits. The Contractor must ensure proper grounding methods are used to eliminate system-wide speaker noise.
4. Speaker circuits shall emanate from panel mounted circuit outputs; field-located addressable modules shall not be used to supervise and control speaker circuits.

E. Visual Notification Circuits

1. Visual Notification Appliance Circuit (NAC) wiring shall be configured as Class A circuits, with a minimum Level 2 pathway survivability from their point of origin to the area served, and Level 1 within the evacuation signaling zone served.
2. The system shall be provided with a minimum of two (2) visual NACs for each floor, evacuation zone or smoke compartment; whichever is greater. The actual number of circuits to be installed shall be coordinated with the supplier's shop drawings.
3. Visual notification appliance circuits shall emanate from panel mounted power supply outputs; field-located addressable modules shall not be used to supervise or control visual appliance circuits.

3.3 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals according to Division 16 Section "Electrical Identification."

B. Install instructions frame in a location visible from the FACP.

3.4 GROUNDING

A. Ground the FACP and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to the FACP.

3.5 FIELD QUALITY CONTROL

A. The system shall be installed and fully tested under the supervision of a trained manufacturer’s representative. The system shall be demonstrated to perform all of the function as specified.

B. The installing contractor or fire alarm equipment vendor shall have no less than two (2) NICET Level IV fire alarm technicians dedicated to this project.

C. The Installing Contract and the Fire Alarm System Vendor shall, upon the request of the Consulting Engineer or End-User, attend any and all project meetings for the purpose of accurately determining progress.

D. It shall be the responsibility of the installing contractor to assure that construction debris does not adversely affect any sensing devices installed as part of this project. Should it be deemed necessary by the Consulting Engineer, End-User or AHJ, the installing contractor shall be responsible for the cleaning of all smoke detectors prior to final acceptance.

3.6 TESTING AND ACCEPTANCE

A. The Contractor is responsible for giving all notices, filing all plans, obtaining all permits, fire alarm system testing and obtaining necessary approvals from authorities having jurisdiction.

B. The authority having jurisdiction, the Fire Department., requests periodic inspection of the fire alarm system during the installation period. The Contractor shall contact the Fire Department to schedule these inspections.

C. The Contractor shall schedule all fire alarm tests a minimum of 2 weeks in advance. Coordinate testing times with the Owner, Designers, and authorities having jurisdiction. Fire Alarm Testing will be performed before or after normal business hours or on weekends and holidays. Additional compensation will not be provided to the Contractor for non-business hours testing.

3.7 FINAL ACCEPTANCE TEST

A. This test is required for issuance of the Certificate of Occupancy by the Fire Department. The Electrical Trade Contractor shall submit to the Fire Department the following documentation prior to requesting the final fire alarm system acceptance test:

1. Affidavit from the fire alarm system designer letter certifying the system has been installed according to plans and specifications and the system is 100% operational and ready for the final testing.
2. Affidavit from the Electrical Trade Contractor letter certifying the fire alarm system has been installed according to the plans and specifications and is ready for final testing.
3. Fire alarm manufacturer completed and signed NFPA Record of Completion form.
4. Copy of the approved Fire Alarm Narrative, Matrix and English language device list.
5. Copy of the fire alarm manufacturer's program notes and approved shop drawings.
6. Copy of the stamped fire alarm drawings (as-built drawings if available).

B. The Contractor shall schedule the final fire alarm test with the Fire Department, the Owner and other required participants.

C. Required participants at the final acceptance test to include:

1. Fire Department
2. General Contractor's site Superintendent
3. Electrical Trade Contractor
4. Owner's Representative
5. If the final acceptance fire alarm test is successful, the Fire Department will issue a letter of acceptance. If the fire alarm test is not successful the Contractor shall immediately provide the required changes and reschedule the fire alarm test.

3.8 TRAINING AND SERVICE

A. Comply with Section 26 00 01.

B. Conduct four 4-hour training sessions. Train the Owner's maintenance personnel on procedures and schedules related to start up and shutdown, troubleshooting, servicing, and preventive maintenance.

C. Training shall include fire department personnel.

3.9 SPARE PARTS

A. Monitor/Control modules (each type): 10

B. Smoke detectors including device base and sensors as applicable: 10

C. Remote Alarm Indicators: 5

D. CO detectors: 5

E. NG detectors: 5

F. Duct smoke detectors including remote test switch: 10

G. Heat detectors including device base and sensors as applicable: 5

H. Notification appliances (each type): 10

I. Pull station including protective covers: 10

End of Section

SECTION 31 10 00
SITE CLEARING

PART 1-GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.2 DESCRIPTION OF WORK

A. Work Included: Provide labor, materials, and equipment necessary to complete the work of this Section, including but not limited to the following:

1. Protecting existing trees and vegetation to remain, including temporary fencing for trees in close proximity to construction operations.
2. Removing existing trees and vegetation indicated to be removed.
3. Clearing and grubbing.
4. Stripping and stockpiling topsoil.
5. Removing above and below grade site improvements.
6. Protection of Existing Utilities.
7. Site clearing activities to remove Phase I (Site Enabling) site improvements.

B. Alternates: Not Applicable.

C. Items to Be Installed Only: Not Applicable.

D. Items to Be Furnished Only: Not Applicable.

E. Related Work: The following items are not included in this Section and will be performed under the designated Sections:

1. Section 312000 – EARTH MOVING for soil materials, excavating, backfilling, and site grading and removal of site utilities.
2. Section 312500 – EROSION AND SEDIMENTATION CONTROLS for required erosion and sedimentation control measures.
3. Section 330505 - SELECTIVE SITE UTILITY DEMOLITION

1.3 DEFINITIONS

A. Topsoil: Natural or cultivated surface-soil layer containing organic matter and sand, silt, and clay particles; friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects more than 2 inches in diameter; and free of subsoil and weeds, roots, toxic materials, or other non-soil materials.

B. Tree Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction, and defined by the drip line of individual trees or the perimeter drip line of groups of trees, unless otherwise indicated.

1.4 MATERIAL OWNERSHIP

A. Except for stripped topsoil or other materials indicated to remain the Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

1.5 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

1. Schedule indicating proposed sequence of operations for demolition work for review prior to start of work. Include coordination for shutoff, capping, and continuation of utility services as required, together with details for dust and noise protection.

a. Provide detailed sequence of demolition and removal work to ensure uninterrupted progress of Owner's on-site operations.

b. Coordinate with Owner's continuing occupation of portions of existing building, adjacent buildings, and with Owner's partial occupancy of completed portions of proposed building or additions.

2. Preconstruction survey photographs sufficiently detailed, of existing conditions of existing buildings, trees and plantings, adjoining construction, and site improvements that might be misconstrued as damage caused by site clearing.

B. Record drawings, according to Section 017700 - CONTRACT CLOSEOUT identifying and accurately locating capped utilities and other subsurface structural, electrical, and mechanical conditions.

1.6 PROJECT CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from the Owner's Representative and authorities having jurisdiction.

2. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

B. Salvable Improvements: Carefully remove items indicated to be salvaged and store on the Owner's premises where indicated.

C. Utility Locator Service: Notify utility locator service for area where Project is located before site clearing.

D. Do not commence site clearing operations until erosion and sedimentation control measures are in place.

E. Protection of Existing Improvements: Provide protection necessary to prevent damage to existing improvements indicated to remain in place or outside of the limit of work. Protect improvements on adjoining properties and on the Owner's property.

1. Restore improvements damaged by Contractor's clearing activities to their original condition, at no additional expense to the Owner.

1.7 EXAMINATION OF SITE AND DOCUMENTS

A. It is hereby understood that the Contractor has carefully examined the site and all conditions affecting work under this Section. No claim for additional costs will be allowed because of a

lack of knowledge of existing conditions as indicated in the Construction Documents, or obvious from observation of the site.

B. Plans, surveys, measurements, and dimensions under which the work is to be performed are believed to be correct, but the Contractor shall have examined them for himself during the bidding period and formed his own conclusions as to the full requirements of the work involved.

PART 2-PRODUCTS (NOT USED)

PART 3-EXECUTION

3.1 PREPARATION

A. Protect and maintain benchmarks and survey control points from disturbance during construction.

B. Locate and clearly flag trees and vegetation to remain or to be relocated.

C. Protect existing site improvements to remain from damage during construction.

1. Restore damaged improvements to their original condition, as acceptable to the Owner's Representative.

3.2 TREE PROTECTION

A. Erect and maintain temporary fencing around tree protection zones before starting site clearing. Remove fence when construction is complete.

1. Do not store construction materials, debris, or excavated material within fenced area.
2. Do not permit vehicles, equipment, or foot traffic within fenced area.
3. Maintain fenced area free of weeds and trash.
4. Except as otherwise directed, cutting and trimming of existing trees will not be permitted.

B. Do not excavate within tree protection zones, unless otherwise indicated.

C. Where excavation for new construction is required within tree protection zones, hand clear and excavate to minimize damage to root systems. Use narrow-tine spading forks, comb soil to expose roots, and cleanly cut roots as close to excavation as possible.

1. Cover exposed roots with burlap and water regularly.
2. Temporarily support and protect roots from damage until they are permanently redirected and covered with soil.
3. Coat cut faces of roots more than 1-1/2 inches in diameter with an emulsified asphalt or other approved coating formulated for use on damaged plant tissues.
4. Backfill with soil as soon as possible.

D. Repair or replace trees and vegetation indicated to remain that are damaged by construction operations, in a manner approved by the Designer.

1. Employ an arborist, licensed in jurisdiction where Project is located, to submit details of proposed repairs and to repair damage to trees and shrubs.
2. Replace trees that cannot be repaired and restored to full-growth status, as determined by the Designer.

3.3 UTILITIES

A. Locate, identify, disconnect, and seal or cap off utilities indicated to be removed.

1. Arrange with utility companies to shut off indicated utilities. The Contractor is responsible for coordinating and scheduling with the authorities having jurisdiction the removal and/or abandonment of existing utilities as required to complete the work.

B. Existing Utilities: Do not interrupt utilities serving facilities occupied by the Owner's Representative or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify the Owner's Representative not less than two days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without the Owner's Representative's written permission.

C. Utility pipes designated to be abandoned in place shall be plugged at their ends with watertight brick masonry or cement mortar with a minimum thickness of 8 inches.

D. Utility pipes designated to be removed shall consist of the complete removal and disposal of the entire length of pipe and backfill and compaction of the void with ordinary borrow. When the void is within the footprint of the new building, gravel borrow shall be used to backfill the void.

E. Utility structures designated to be abandoned in place shall have their cast iron castings removed and disposed, inlet and outlet pipes plugged, the bottom of the structures shall be broken, the void of the structure shall be backfilled and compacted with ordinary borrow, and the top of the structure shall be removed so that it is at least 36 inches below finished grade.

F. Utility structures designated to be removed shall consist of the removal and disposal of cast iron castings, plugging of inlet and outlet pipes, removal of the structure, and backfill and compaction of the void with ordinary borrow. When the void is within the footprint of the new building, gravel borrow shall be used to backfill the void.

3.4 CLEARING AND GRUBBING

A. Remove obstructions, trees, shrubs, grass, and other vegetation to permit installation of new construction.

1. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.
2. Cut minor roots and branches of trees indicated to remain in a clean and careful manner where such roots and branches obstruct installation of new construction.
3. Grind stumps and remove roots, obstructions, and debris extending to a depth of 18 inches below exposed subgrade.
4. Use only hand methods for grubbing within tree protection zone.
5. Chip removed tree branches and dispose of off-site.

B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.

1. Place fill material in horizontal layers not exceeding a loose depth of 8 inches and compact each layer to a density equal to adjacent original ground.

3.5 TOPSOIL STRIPPING

A. Remove sod and grass before stripping topsoil.

B. Strip topsoil to whatever depths are encountered in a manner to prevent intermingling with underlying subsoil or other waste materials.

1. Remove subsoil and nonsoil materials from topsoil, including trash, debris, weeds, roots, and other waste materials.

C. Stockpile topsoil materials away from edge of excavations without intermixing with subsoil. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust or contamination by air-borne weed seed.

1. Limit height of topsoil stockpiles to 72 inches.
2. Do not stockpile topsoil within tree protection zones.

3.6 EXCESS TOPSOIL

A. Topsoil that has been stripped and stockpiled, but is not needed after the completion of all final topsoil spreading and grassing, shall be removed and legally disposed of off site by the Contractor per local, state, and federal standards.

3.7 SITE IMPROVEMENTS

A. Remove existing above- and below-grade improvements as indicated and as necessary to facilitate new construction.

B. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.

1. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut length of existing pavement to remain before removing existing pavement. Saw-cut faces vertically.
2. Paint cut ends of steel reinforcement in concrete to remain to prevent corrosion.

3.8 DISPOSAL

A. Disposal: Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off the Owner’s property.

1. Burning on site is prohibited.
2. Separate recyclable materials produced during site clearing from other nonrecyclable materials. Store or stockpile without intermixing with other materials and transport them to recycling facilities.

3.9 CLEANUP AND REPAIR

A. General: Upon completion of demolition work, remove tools, equipment, and demolished materials from site.

B. Repair demolition performed in excess of that required. Return elements of construction and surfaces to remain to condition existing prior to start operations. Repair adjacent construction or surfaces soiled or damaged by site demolition work.

End of Section

Section 31 20 00

EARTH MOVING

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.2 SPECIAL INSTRUCTIONS

A. The Contractor shall become familiar with other Sections of the Specifications to determine the type and extent of work there under which affects the work of this section whether or not such work is specifically mentioned.

A. The conditions of the Order of Conditions, issued by the City of Worcester Conservation Commission for this project, shall be met by the Contractor.

1.3 DESCRIPTION OF WORK

A. Work Included: Provide labor, materials, services, and equipment, including all items incidental thereto, necessary to complete the work as specified in this Section and as shown in the drawings, including but not limited to the following:

1. Control of surface water runoff, dust control and clean up during construction.
2. Excavating all types of materials to limits indicated or required, including soil, rock, and other materials for new, below-grade construction and other site improvements as shown on the Drawings. All topsoil, subsoil, root balls, organic soil, existing fill, and other deleterious matter should be entirely removed from within the proposed building footprint. All topsoil, subsoil, organic material, root balls, and other deleterious material shall be entirely removed from within the paved areas. The existing fill shall be improved under the subbase of paved areas.
3. Excavation, covering, and backfilling of onsite soils, as required during construction.
4. Coordination of all disposal activities as required to complete the work described in this Section and as required/detailed in the contract document. The site contractor shall be responsible for the cost of legal disposal, off-site, including permitting and/or fees, of all unsuitable or surplus excavated and or stockpiled materials.
5. Coordination of material testing shall be the responsibility of the Contractor as outlined under testing requirements. All imported material tested shall be under ASTM D442 and shall be paid for by the Contractor.
6. Furnishing, from an approved borrow source or processing material onsite, fill or backfill materials for placement and compaction on site as required to complete the work of this section.
7. Furnishing and installing shoring, sheeting, and support of excavations.
8. Dewatering excavations as required to construct all foundations and place all backfill “in the dry” (i.e., 12 inches beneath the bottom of excavations). Obtaining and maintaining all permits required for legal discharge of groundwater and run-off. The Contractor shall be responsible for control, pumping, and disposal of groundwater, precipitation or other water which accumulates in the excavation to allow all below-grade construction to be conducted in-the-dry.

9. Proof rolling trenches and excavations.
10. Excavation, bedding, backfill and compaction for:

    a. Building footings, slabs, walls, pads, bases, sidewalks, etc.
    b. Drainage piping and field subdrains, structures, etc.
    c. Electrical and utility lines, conduits, light poles, light pole feeds, transformers and other utility pads.
    d. Sanitary sewer piping.
    e. Water and fire service,
    f. All pads, posts, stairs, and items indicated on the drawings.
    g. Parking areas, handicap parking areas, ramps, curb cuts, etc.
    h. Data/communications service conduits and piping.
    i. Fill slopes and site retaining walls.
    j. All other work indicated on the drawings requiring excavation, backfill and/or compaction including but not limited to excavation and backfill for all trades inside the new building footprint.

11. Adjusting all manhole and catch basin frame and grates for all utilities where grades are adjusted, and structures are to remain.
12. Coordinating with all trades for complete building systems as follows:

    a. Water service: Provide and install all excavation and backfill. Sleeve concrete as directed by the Subcontractors. Coordinate all work and comply with all the requirements of the controlling municipal agency.
    b. Electrical service: Excavation, bedding, backfill, concrete encasement, and precast light pole bases for the electric service. The conduits shall be provided and installed under Section 260000 ELECTRICAL.
    c. Communications: Telephone and spare conduits shall be provided and installed by the electrical contractor. Excavation, backfill, and the concrete encasement shall be provided by the General Contractor.
    d. Gas service: Gas service pipes and appurtenances shall be provided and installed by the Gas Company. The General Contractor shall provide excavation and backfill for the gas services to the new building from the limit of the public way. The Gas Company will provide excavation and backfill for gas service installation within the public way.
    e. Excavation, bedding, and backfill for all interior utilities, including underground electrical, foundations, and work.

13. Soil around the school, under recreation areas, and plantings adjacent to occupied areas shall be clean material with less than 20 ml/l of arsenic. Areas where arsenic concentrations are higher must have fabric warning layer and 12 inches of clean fill, or 36 inches of clean fill with no fabric warning layer or be placed under pavement section (asphalt and base course material) as indicated in the Drawings and indicated in plans and specifications prepared by the Licensed Site Professional.
14. Erosion and sedimentation control.
15. All engineering and survey work to verify existing conditions and layout the complete construction. See Section 31 10 00, SITE PREPARATION.
16. Providing, operating, and maintaining all temporary shoring and/or hoisting equipment and provide, maintain, and remove all staging and scaffolding, and rigging required for all work.
17. Contractor shall be responsible for notifying all affected utility companies and Digsafe before starting work.

18. Installing fencing and safety devices or controls as specified and as necessary.

B. Related Work: The following items are not included in this Section and will be performed under the designated Sections:

1. SECTION 01 12 00 PROJECT PHASING REQUIREMENTS
2. SECTION 02 41 17 – BUILDING DEMOLITION for demolition and foundation removal of buildings and site walls
3. SECTION 31 10 00 – SITE CLEARING for site stripping, grubbing, stripping and stockpiling topsoil, and removal of above- and below-grade improvements.
4. SECTION 31 25 00 – EROSION AND SEDIMENTATION CONTROLS for temporary erosion and sedimentation control measures.
5. Division 02, 22, 23, and 26 Sections for installing underground mechanical and electrical utilities and buried mechanical and electrical structures.
6. SECTION 33 10 00 – WATER UTILITIES for installing underground water pipes, valves, hydrants, and appurtenances.
7. SECTION 33 30 00 – SANITARY SEWERAGE UTILITIES for installing underground sewer pipes and manholes.
8. SECTION 33 40 00 – STORM DRAINAGE UTILITIES for installing underground drain pipes, manholes, area drains, water quality structures, and water storage tanks.

1.4 UNIT PRICES

A. Unit prices for certain types of earthwork are included.

B. Rock Measurement: Volume of rock actually removed. Unit prices for rock excavation include replacement with approved materials.

1.5 DEFINITIONS

A. Backfill: Soil material or Controlled Density Fill (CDF) used to fill an excavation.

1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
2. Final Backfill: Backfill placed over initial backfill to fill a trench.

B. Base Course: Course placed between the subbase course and hot-mix asphalt paving and concrete paving.

C. Bedding Course: Course placed over the excavated subgrade in a trench before laying pipe.

D. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.

E. Dewatering includes lowering the water table to 12 inches beneath the bottom of excavations and intercepting seepage which would otherwise emerge from the slopes or bottom of the excavation; increasing the stability of excavated slopes; preventing loss of material from beneath the slopes or bottom of the excavation; reducing lateral loads on sheeting and bracing; improving the excavation and hauling characteristics of sandy soil; preventing rupture of heaving of the bottom of any excavation; and disposing of pumped water.

1. Normal dewatering is defined as using conventional pumps installed in open excavations ditches, or sumps.

F. Drainage Course: Course supporting the pavement that also minimizes upward capillary flow of pore water.

G. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.

1. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by the Owner's Representative or the Designer. Authorized additional excavation and replacement material will be paid for according to Contract provisions for unit prices.
2. Trench Excavation and Bulk Excavation: A trench excavation is an excavation of any length where the width is less than twice the depth and where the shortest distance between payment lines does not exceed ten (10') feet. All other excavations shall be defined as bulk excavations.
3. Unauthorized Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions without direction by the Owner's Representative or the Designer. Unauthorized excavation, as well as remedial work directed by Designer, shall be without additional compensation.

H. Fill: Soil materials used to raise existing grades.

I. Rock: Rock material in beds, ledges, unstratified masses, conglomerate deposits, and boulders of rock material that cannot be removed by normal rock excavating equipment without systematic drilling, ram hammering, ripping, or blasting, when permitted.

J. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, stairs, hardscapes, exterior pads, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.

K. Subbase Course: Course placed between the subgrade and base course for hot-mix asphalt pavement, or course placed between the subgrade and a cement concrete pavement or a cement concrete or hot-mix asphalt walk.

L. Subgrade: Surface or elevation remaining after completing excavation, or top surface of a fill or backfill immediately below subbase, drainage fill, or topsoil materials.

M. Utilities: Onsite underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

N. Unsuitable Soils: Excavated soils that are determined by the Designer to not be reusable as fill or backfill on-site due to gradation, moisture content, and/or the presence of organic matter or other deleterious materials.

1.6 SUBMITTALS

A. Product Data: For the following:

1. Each type of plastic warning tape.
2. Geotextile.
3. Controlled Density Fill, including design mixture.

B. Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated:

1. Classification according to ASTM D 2487 of each onsite and borrow soil material proposed for fill and backfill.
2. Laboratory compaction curve according to ASTM D 1557 for each onsite and borrow soil material proposed for fill and backfill.

C. Submit a detailed construction sequence plan for project excavation indicating temporary stockpile areas, side slopes of excavations, limits of required temporary excavation support and sequence, and procedures for subgrade protection, excavation, concrete placement, moisture conditioning of onsite excavated soils used as fill, filling, backfill, and compaction.

D. Provide procedure and onsite test areas for any soils, crushing, mixing, testing, an installation of existing site soils including in situ compaction and testing.

E. Backfill Materials: Provide 50-pound sample for third-party testing of each backfill material from each proposed source, including on-site materials. Submit a grain size analysis and distribution curve performed in accordance with ASTM D422 for each proposed backfill material for review by the Engineer. The sieve analysis will be based on a washed sieve test. Additional samples and analysis shall be submitted if a change in material occurs at the borrow source. Material that is processed by crushing of onsite materials shall be tested for compliance with the gradation requirements specified herein at the Contractor's expense. The Geotechnical Engineer will review the suitability of fill materials. Installation of materials prior to testing and/or review and response by Architect is at Contractor's risk. Contractor shall remove materials that were placed and which do not meet the gradation requirements as required by the Owner at the Contractor's expense.

F. Submit the name of each material supplier and specific type and source of each material. Any change in source throughout the job requires approval of the Architect or Geotechnical Engineer. No fill material shall be delivered to the site or placed until the material has been approved.

G. Soil Samples:

1. Initial soil testing shall be performed by a third party and coordinated and paid for by the General Contractor. A plan indicating the location of each soil sample shall be provided for each test. If approval is based on the test results from a sample of material to be imported, additional tests, including grain-size analyses and laboratory compaction tests should be performed on the material after it is delivered to the site.
2. Classification in accordance with ASTM D422 preferred or D2487 for each on-site or borrow soil material proposed for use onsite. Test shall include at a minimum the following sieves: #200, #60, #40, #20, (#10 or #8), #4, ½-inch, ¾-inch, 1 ½-inch, and-3 inch.
3. Laboratory compaction curve in accordance with ASTM D1557 for each on-site or borrow soil material.
4. The Contractor shall submit a scale plan daily that defines the location, limits, and depths of the area excavated.
5. Particle size analysis in accordance with ASTM D422 with gradation curves and envelope corresponding to the specified material. The sieve analysis will be based on a washed sieve test but will not require a hydrometer test unless requested by the Architect. The gradation curve must be entirely within the specified envelope for a material to be approved for use.
6. Soil samples from all on-site materials that are processed on site shall be sieve tested. The sieve test results shall be submitted to the design team for every 500 cubic yards of material prepared on-site.

7. Architect will be sole and final judge of suitability of all materials. Remove rejected materials and replace with new, whether in stockpiles or in place.

H. Submit a detailed construction sequence plan for project excavation indicating temporary stockpile areas, side slopes of excavations, limits of any required temporary excavation support and sequence and procedures for slope protection, subgrade protection, excavation, concrete placement, moisture conditioning of on-site excavated soils used as fill, filling, backfill, and compaction.

I. Dewatering system: Contractor shall submit, for record, drawings and design data prepared, stamped, and signed by a registered professional engineer in the Commonwealth of Massachusetts who is experienced in groundwater control system design. The submittal shall show arrangement locations, depths, and details of wells and well points and sump pumps; locations of risers, headers, filters, pumps, power units, all treatment components, and discharge lines; and means of discharge, control of sediment, and disposal of water. The submittal of the dewatering system will not relieve the Contractor from the responsibility for the adequacy of the dewatering system to achieve the required results specified in these Specifications and all permit requirements.

1. Include layouts of piezometers and flow-measuring devices for monitoring performance of dewatering system.
2. Include a written plan for dewatering operations including control procedures to be adapted if dewatering problems arise.
3. Include design calculations demonstrating adequacy of the proposed dewatering system and equipment.
4. Provisions and methods of sediment removal and disposal of water.
5. All permits required for the work.

J. Support of Excavation: Contractor shall submit, for record, proposed excavation support systems (if required). The proposed lateral support systems shall be designed and stamped by a registered professional engineer licensed in the Commonwealth of Massachusetts. Despite the submittal of the design of excavation support and protection systems, the Contractor shall remain solely responsible for the adequacy and safety of materials and methods used in construction. Include the following as a minimum on the drawings:

1. Details, including type, location, length, and depth of system, arrangements, and methods of construction of the proposed system(s).
2. The method of installation and installation equipment.
3. The elevation of struts, shores, and tiebacks, as applicable, and permissible depth to which excavation may be carried before such supports are installed.
4. The excavation depths, the depth below the main excavation to which the support system will be installed, and the maximum design load to be carried by various members of the support system.
5. Design calculations including references to design methods used, assumptions, design parameters, design soil profile, material properties, allowable stresses, and other pertinent information stamped by a Professional Engineer registered in the Commonwealth of Massachusetts.
6. The location of existing utilities, facilities and/or structures nearby.
7. Instrumentation, including types and locations of deformation monitoring points (DMPs), frequency of monitoring of the DMPs, and action plan in the event the DMP movements exceed the established thresholds.

K. Pre-excavation Photographs and Videotape: Show existing conditions of adjoining construction and site improvements, including finish surfaces, that might be misconstrued as damage caused by earthwork operations. Submit before earthwork begins. Maintain catalog of up-to-date photographs at the site.

L. Plan to Maintain Safe Path of Travel: Submit plans for maintaining safe paths of travel for the general public during the entire project, including requirement for police details if necessary.

M. Filter fabric: Submit the manufacturer's information and a one square foot representative sample of the filter fabric.

N. Within one week after making field adjustments, resubmit revised working drawings as necessary to reflect changes required by field conditions.

O. Obtain required permits for discharge of dewatering effluent. Submit two copies of all permits obtained at least one week prior to system installation.

1.7 REFERENCE STANDARDS

A. The following standards are applicable to the work of this section to the extent referenced herein or if the item is indicated on the Drawings or specified without a detail.

1. City of Worcester Standard Specifications and Details, latest edition.
2. MassDOT Construction Standards, latest edition with amendments, hereinafter referred to as the “Construction Standards”.
3. ASTM: American Society for Testing and Materials.
4. S.S.H.B. Standard Specifications for Highways and Bridges, the Commonwealth of Massachusetts, Department of Public Works, latest edition.

B. See the Appendix to this specification for previous soil test results for material processed on site.

1.8 COORDINATION

A. Prior to start of earthwork, the Contractor shall arrange an onsite meeting with the Architect, Engineer, the Geotechnical Engineer, and the testing agency for the purpose of establishing the Contractor's schedule of operations and scheduling observation and testing procedures and requirements as further described in Section 1.18.

B. As construction proceeds, the Contractor shall be responsible for notifying the Geotechnical Engineer and the testing agency prior to the start of earthwork operations requiring observation and/or testing.

C. The work of this Section shall be coordinated with that of other trades affecting, or affected by, this work, as necessary to ensure the steady progress of all work of the Contract.

1.9 PROJECT CONDITIONS

A. Existing Utilities: Do not interrupt utilities serving facilities occupied by the Owner or others except in accordance with the Construction Manager’s project phasing requirements provided in Specification Section 01 12 00, or unless permitted in writing by the Owner’s Representative and then only after arranging to provide temporary utility services according to requirements indicated.

1. Notify the Owner's Representative not less than two days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without the Owner's Representative's written permission.
3. Contact utility-locator service for area where Project is located before excavating.

    a. The Contractor shall notify "Dig Safe" at 1-888-DIG-SAFE prior to commencing any excavation work.

B. Demolish and completely remove from site existing underground utilities and structures indicated to be removed. Coordinate with utility companies to shut off services if lines are active.

C.

D. Survey Work: Contractor shall engage a qualified land surveyor or professional engineer to survey adjacent existing buildings, structures, and site improvements; establish exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.

    1. During earth moving operations, installation of excavation support and protection systems and dewatering, regularly resurvey benchmarks, maintaining an accurate log of surveyed elevations and positions for comparison with original elevations and positions. Promptly notify Owner's Representative if changes in elevations or positions occur or if cracks, sags, or other damage is evident in adjacent construction.

E. The Contractor shall not close or obstruct any street, sidewalk, or passageway without written permission from authorities having jurisdiction unless otherwise indicated on the Contract Drawings. Refer to the Temporary Traffic Control Plans included in the Contract Drawings related to the closure of Lake Street. The Contractor shall conduct the construction operations as to minimize interference with the use of roads, driveways, or other facilities near enough to the project to be affected by the work.

F. The Contractor shall provide police details when working in roadways, as required by local jurisdictional authorities. The Contractor shall pay for any and all police details.

1.10 SUBSURFACE CONDITIONS

A. A eotechnical report dated March 8, 2021 and attached to Section 31 00 00 Subsurface Investigation has been prepared for this Project and is hereby made part of the Contract Documents. The information in the geotechnical report is made available for information only for the convenience of the Bidders. Neither the Owner nor Geotechnical Engineer represent to the Contractor that the information is either an accurate or a comprehensive indication of subsurface conditions. Bidders are invited to review the information to apprise themselves of the information available, and also to make additional investigations at their own expense. Neither the Owner nor the Geotechnical Engineer will be responsible for interpretations or conclusions drawn from the data.

B. The geotechnical report does not represent and shall not be construed to represent a guarantee of subsurface conditions. Interpretation of this data for purposes of construction is the responsibility of the Contractor. It is the Contractor's responsibility to make interpretations and draw conclusions with respect to the character of materials to be encountered and groundwater conditions at the site and their impact upon Contractor's work based on his

expert knowledge of the area, construction dewatering methods, and support of excavation methods.

C. Make additional test borings and conduct other exploratory operations necessary for dewatering and excavation support and protection.

D. Test boring and test pit locations as depicted on the Drawings are located by tape measurements from existing site features and structures are approximate and so are the elevation interpolated for the borings and test pits.

E. The Contractor shall visit the site prior to submitting a bid to become familiar with the extent of the work to be done under this Contract. The Contractor shall be responsible for determining the quantities of earth materials necessary to complete the work under this Section.

F. The Geotechnical Report indicates that the majority of the materials present at the site contain quantities of fines beyond the limit deemed acceptable for reuse by the specification. The Contractor is made aware of this condition and will not be eligible to receive additional compensation exceeding the Contractor’s initial bid for imported material.

G. The Owner assumes no responsibility for the Contractor's failure to make his own site investigation and makes no representation of subsurface conditions. Failure by the Contractor to be aware of existing site conditions shall not be cause for additional cost to the Owner. Information on subsurface conditions is made available for the convenience of the Bidders. The Owner does not present the information to the Contractor as either an accurate or a comprehensive indication of subsurface conditions. Bidders are invited to review the information to apprise themselves of the information available, and also to make additional investigations at their own expense.

H. No claim for extra cost or extension of time resulting from reliance by the Contractor on information presented herein shall be allowed, except as provided in the Contract Documents.

1.11 REUSE OF ONSITE MATERIALS

A. The Contractor may re-use onsite excavated soils that meet the gradation requirements of materials specified herein, at locations where specified.

B. The Contractor may utilize a crusher onsite to blend and crush blasted rock, boulders, and overburden soils and suitable building materials to produce materials that meet the gradation requirements specified herein for reuse onsite.

C. The processing of the existing building concrete and brick materials into Ordinary Fill shall be allowed under Section 02 41 17 Building Demolition.

D. Excavated on-site soils which are suitable for re-use at the time of excavation but become frozen or too wet for re-use due to poor material handling practices shall be disposed of off-site and replaced as necessary at no additional cost to the Owner.

E. Excavation material free of organic matter and approved for re-use by the environmental professional can be placed in paved areas at depths greater than 3 feet below the bottom of the subbase layer provided that the maximum particle size is less than 2/3 of the lift thickness and that the material is compacted to a minimum relative compaction of 95 percent.

F. Excavation material free of organic matter and approved for re-use by the environmental professional can be placed in landscape areas at depths greater than one foot below the bottom of the subbase layer provided that the maximum particle size is less than 2/3 of the lift thickness and that the material is compacted to a minimum relative compaction of 92 percent. In areas beyond the outer loop of the access road, existing material may be placed to the underside of the finish loam layer.

G. The Contractor is cautioned that the onsite materials may be high in fines. Materials with high fines contents are typically difficult to handle when wet as they are sensitive to moisture content variations. Subgrade support capacities may deteriorate when such soils become wet and/or disturbed. The contractor shall keep exposed subgrades properly drained and free from ponded water. Subgrades shall be protected from machine and foot traffic to reduce disturbance. Placed onsite material that become soft and unsuitable to support additional lifts of fill shall be removed and replaced at no additional cost to the owner.

H. Refer to the Geotechnical Engineering Report for conditions of reuse of existing soil below building structures.

1.12 EXCAVATION

A. The Contractor shall perform all excavations and of whatever materials encountered, in a manner as required to allow for placing of temporary earth support, forms, installation of pipe and other work, and to permit access for the purpose of observing the work. Excavations shall be to such widths as will give suitable space for the required work. Bottoms of trenches and excavations shall be protected from frost and shall be firm, dry and in an acceptable condition to receive the work. Work shall not be placed on frozen surfaces nor shall work be placed on wet or unstable surfaces.

B. All excavations made in open cut will be controlled by the conditions existing at that location. In no case shall earth be excavated or disturbed by machinery so near to the finished subgrade for structures and pipelines as to result in the disturbance of the earth below the subgrade. The final excavation to subgrade should be accomplished with a smooth faced bucket or by hand.

1.13 EXCAVATION SUPPORT AND PROTECTION

A. The Contractor shall furnish, install, monitor and maintain excavation support and protection systems (sheeting, shoring, and bracing) at locations necessary to support the sides of excavations and resist soil and hydrostatic pressure and superimposed and construction loads; to prevent danger to persons or damage to adjacent pavements, facilities, utilities, or structures; to prevent injurious caving or erosion or the loss of ground; and to maintain pedestrian and vehicular traffic as required by the Contract Documents, the Contractor’s sequence of construction, and as directed by the Owner’s Representative.

B. In all sheeting, shoring and bracing operations, care shall be taken to prevent collapse of excavations, injury to persons or damage to adjacent structures, facilities, utilities, and services. Any injuries to persons shall be the responsibility of the Contractor; and any damage to the work occurring as a result of settlement, water or earth pressure, or other causes due to inadequate bracing or other construction operations of the Contractor shall be satisfactorily repaired and made good by the Contractor, at no additional cost to the Owner.

C. The excavation support system shall be of sufficient strength and be provided with adequate bracing to support all loads to which it will be subjected. The excavation support system shall

be designed to prevent any movement of earth that would diminish the width of the excavation or damage or endanger adjacent structures.

D. Where sheeting is to be used, it shall be driven ahead of excavation operations to the extent practicable so as to avoid the loss of material from behind the sheeting; where voids occur outside of the sheeting, they shall be filled immediately with ordinary fill, thoroughly compacted.

E. The Contractor shall leave in place all sheeting and bracing at the locations and within the limits ordered by the Owner's Representative in writing. The Contractor shall cut off the sheeting at elevations as indicated on the Contract Drawings or be determined with the approval of the Owner's Representative.

F. The Contractor shall comply with all federal, state, and local safety regulations, and requirements.

1.14 DEWATERING

A. The Contractor shall provide, at his own expense, adequate pumping and drainage facilities to maintain the excavated area sufficiently dry from groundwater and/or surface runoff, i.e., maintain the groundwater level at least 12 inches beneath the bottom of the excavation, so as not to adversely affect construction procedures nor cause excessive disturbance of underlying natural ground. The flows of all water resulting from pumping shall be managed so as not to cause erosion, siltation of drainage systems, or damage to adjacent property.

B. Any damage resulting from the failure of the dewatering operations of the Contractor, and any damage resulting from the failure of the Contractor to maintain all the areas of work in a suitable dry condition, shall be repaired by the Contractor, as directed by the Owner's Representative and/or the Designer, at no additional cost to the Owner. The Contractor's pumping and dewatering operations shall be carried out in such a manner as to prevent damage to the Contract work and so that no loss of ground will result from these operations. Precautions shall be taken to protect new work from flooding during storms or from other causes. Pumping shall be continuous to protect the work and/or to maintain satisfactory progress.

C. All pipelines or structures not stable against uplift during construction or prior to completion shall be thoroughly braced or otherwise protected. Water from the trenches, excavations, and stormwater management operations shall be disposed of in such a manner as to avoid public nuisance, injury to public health or the environment, damage to public or private property or damage to the work completed or in progress.

D. The Contractor shall control the grading in the areas surrounding all excavations so that the surface of the ground will be properly sloped to prevent water from running into the excavated area. Where required, temporary ditches shall be provided to control drainage. Upon completion of the work and when directed, all areas shall be restored by the Contractor in a satisfactory manner and as directed.

E. Remove dewatering system when no longer required for construction.

F. The Contractor shall obtain and maintain all required local, state, and federal permits necessary for construction dewatering for the duration of dewatering activities including all chemical testing required for disposal and discharge of dewatering effluent. The Contractor shall be responsible for treatment of water, if necessary, to meet minimum discharge criteria specified in the permits.

1.15 QUALITY CONTROL

A. The Owner may retain and pay for the services of an independent testing agency to monitor backfill operations and to perform field density tests, and a Geotechnical Engineer to periodically observe the earthwork operations and observe the preparation of the subgrade for building footings, slabs, The Civil Engineer will periodically make visual observations of the site pavement construction, other related site construction, and utility excavations. The Geotechnical or Civil Engineer may from time-to-time request that the Contractor excavate tests pits ahead of excavation to confirm subsurface conditions.

B. The Contractor shall make provisions for allowing observations and testing of Contractor's Work by the Geotechnical or Civil Engineer and by the independent testing and inspection firm. The presence of the independent testing agency and/or the Geotechnical Engineer does not include supervision or direction of the actual work of the Contractor, his employees or agents. Neither the presence of the independent testing agency and/or the Geotechnical Engineer, nor any observations and testing performed by them, nor failure to give notice of defects shall excuse the Contractor from defects discovered in his work.

C. If fill soils are not obtained from a commercial gravel pit, the Contractor shall provide certified analytical testing of offsite backfill to demonstrate that the soil does not exceed the limitations for MCP reference/reportable concentrations. Analyses shall include RCRA-8 metals, Extractable and Volatile Petroleum Hydrocarbons (EPH/VPH), and Volatile Organic Compounds (by EPA Method 8260B/5035). No testing will be required of imported fill soils obtained from a commercial gravel pit, provided the soils are free of odors, discoloration, staining or other conditions indicative of contamination, in the opinion of the Geotechnical Engineer and/or the Designer.

D. Costs related to retesting due to unacceptable quality of work and failures discovered by testing shall be paid for by the Contractor at no additional expense to Owner, and the costs thereof will be deducted by the Owner from the Contract Sum.

E. Tests and analysis of soil material will be performed in accordance with ASTM D422, ASTM D1557, ASTM D2922, ASTM D3017 and ASTM D4318.

F. If tests indicate materials do not meet specified requirements, the Contractor shall identify an alternative borrow source, test the new material, and submit results to the Designer at no cost to Owner.

1.16 EXCAVATION CLASIFICATIONS

A. Additional Excavation:

1. When excavation has reached required subgrade elevations, notify the Owner's Representative who will review subgrade conditions.
2. If unsuitable bearing materials are encountered at the required subgrade elevations, carry excavations deeper and replace excavated material as directed.
3. Removal of unsuitable material beyond the grades and lines shown on the Drawings and specified herein and its replacement as directed will be paid on the basis of contract conditions relative to changes in work or as provided for under the unit rates for this classification.

B. Rock Excavation:

1. Rock excavation in trenches includes removal and disposal of materials and obstructions encountered which cannot be excavated with a 1.0 cubic yard (heaped) capacity, 42-inch-wide bucket on medium-size track-mounted hydraulic excavator equivalent to Caterpillar Model 215, rated at not less than 90HP flywheel power and 30,000 lb. drawbar pull. Trenches in excess of 10-feet in width are classified as open excavation.
2. Rock excavation in open excavations includes removal and disposal of materials and obstructions encountered which cannot be dislodged and excavated with modern track-mounted heavy-duty hydraulic excavating equipment without drilling or ripping. Rock excavation equipment is defined as Caterpillar Model No. 973 or No. 977K, or equivalent track-mounted loader, rated at not less than 170HP flywheel power and developing 40,000-lb. breakout force (measured in accordance with SAE J732C).
3. Determination of rock excavation classification will be made by the Owner's Representative. Typical of materials classified as rock are boulders 3.0 cubic yards or more in volume, solid rock, rock in ledges, and rock-hard cementitious aggregate deposits. Intermittent drilling or ripping performed to increase production and not necessary to permit excavation of material encountered will be classified as earth excavation. Do not perform rock excavation work until material to be excavated has been cross-sectioned and classified by the Owner's Representative. Visual observation of the completed excavation may be made by the Owner's Representative to modify the excavation classifications. Removal of rock excavation prior to classification by the Owner's Representative shall be considered as earth excavation unless accepted by the Owner's Representative in writing. Rock excavation will be paid on the basis of contract unit rates for this classification.
4. Rock payment lines (if applicable) are limited to the following:

    a. Two feet outside of concrete work for which forms are required.
    b. In pipe trenches, depth limits shall be 6 inches below the bottom of the pipe:

Depth From Ground Surface to Invert of Pipe	Pay Width (Pipe ID)	
	0-24”	Over 24”
0 to 12’	5’-0”	Pipe I.D. +3’-0”
12’ to 20’	7’-0”	Pipe I.D. +7’-0”
Over 20’	9’-0”	Pipe I.D. +7’-0”

    c. Payment lines for columns and footings within the building shall be a vertical line one foot from the toe of the footings; the depth shall be measured at 12 inches below the bottom elevations shown on the Drawings. Payment lines for rock excavation under slabs on grade shall be 12 inches below the bottom elevation of the specified gravel base course outside of the building and 24 inches below subgrade for slabs within the building.
    d. Payment lines for manholes, catch basins, and other utility structures shall be one foot outside of the outer wall and six inches below the bottom of the base material beneath the structure.
    e. Rock sloping across the width of trench shall have the top of rock established at the rock elevation over the centerline of the pipe.

5. Measurement

a. When, during the process of excavation, rock is encountered, it shall be uncovered and exposed in such a manner that the unbroken ledge surface is clearly visible, and the
b. Architect shall be notified by the Contractor, before proceeding further. The areas in question shall then be cross sectioned as hereinafter specified.
c. Failure on the part of the Contractor to uncover the rock surface and to notify the Architect and proceeding by the Contractor with the rock excavation before cross-sections are taken, will forfeit the Contractor's right of claim towards the stated allowance or additional payment over and above the stated allowance at the quoted unit price.
d. The Contractor shall employ and pay for a licensed Registered Civil Engineer or Land Surveyor to take cross-sections of rock before removal and to make computations of volume of rock encountered within the Payment Lines. Cross-sections shall be taken in the presence of the Geotechnical Engineer and the computations approved by the Architect. The Owner has the option to perform independent cross-sections and computations of rock quantities.

C. Determination of Actual Quantities

1. The contractor shall provide all excavation to expose the top of ledge in any area requiring excavation by blasting.
2. After exposing top of rock, Architect shall be notified and the top of rock shall be cross sectioned by a registered engineer or professional land surveyor as approved by Architect and paid for by the contractor.

    a. Any rock removed prior to notification of the Architect and subsequent cross sectioning shall be considered general excavation and any payment for rock shall not apply.
    b. Cross sections of rock shall be created as needed for accurate definition of rock removed. Maximum stationing allowed will be 25 feet. Include the following items on the cross section:
        1) Existing ledge
        2) Items of construction and pay limits
            a) Roads
            b) Utilities with inverts
            c) Rock slopes
            d) Finished grades.
        3) Actual rock removed.

    c. Cross sections shall clearly differentiate between trench and open excavation rock quantities.

3. The Contractors Engineer or Surveyor shall calculate the difference between the profiled top grade and the excavation limit indicated material in place. No additions for expansion after removal are allowed.

    a. Sealed calculations, work sheets and cross sections shall be submitted to Architect for approval.

4. If alternate methods of rock removal are employed (pre-splitting or other methods) the contractor is required to verify the top of rock, as defined above, to the satisfaction of

the Architect. Failure to meet the Architect's requirements will be cause to consider all rock so removed as general excavation.

D. All ordinary site earthen excavations are unclassified.

1. All building excavation limits are to be removed in their entirety. All fill materials placed as part of the original site's earthwork operations. Reference the published soils borings and test pits that indicate the strata change between fill and original soils for vertical excavation limits.
2. Horizontal limits shall extend beyond the proposed building footprint a distance equal to the distance between the bottom of the proposed footings and the natural soil or 5 feet, whichever is greater.
3. All fill within the building from the above noted excavations to the bottom of interior slab crushed stone base or as defined in the documents shall be structural fill.

E. Unit Prices

1. Unit prices for rock excavation, shall include the full compensation for all required labor, products, tools, equipment, plant, transportation services and incidentals required for excavation and transport of excavated materials; establishment of subgrade; and mark-up for overhead and profit.
2. Materials, methods of installation and definitions of terms set forth under the various unit price items are indicated in the Schedule of Unit prices and indicated in the Contract Documents.
3. The payment lines for rock excavation shall be as indicated in the Contract Documents or specified herein.

    a. Rock Measurement: Volume of rock actually removed, measured in original position, but not to exceed the following:

        1) 24 inches (600 mm) outside of concrete forms other than at footings.
        2) 12 inches (300 mm) outside of concrete forms at footings.
        3) 12 inches below bottom of footing.
        4) 12 inches (150 mm) outside of minimum required dimensions of concrete walls cast against grade.
        5) 6" Outside dimensions of concrete walls indicated to be cast against rock without forms or exterior waterproofing treatments.
        6) 24 inches (150 mm) beneath bottom of concrete slabs on grade.
        7) 12 inches (150 mm) beneath pipe in trenches, and the greater of 24 inches (600 mm) wider than pipe or 42 inches (1065 mm) wide.
        8) Payment lines for manholes and catch basins and drainage structures shall be one 12" outside of the outer walls and six 12 inches below the bottom of the structure.
        9) Face of exposed rock slope as directed by the geotechnical engineer.
        10) 24" below proposed finished grades in lawn and planted areas.
        11) 12 inches below bottom of subgrade layer for light duty and heavy-duty pavements.
        12) 12 inches below bottom of designed section as shown on the details for all specialty paving and concrete paving and concrete pads.

4. Performance of work which is not required under the Contract Documents or which is not authorized by Change Order, whether or not such work item is set forth hereunder as a Unit Price Item, shall not be considered cause for any extra payment. The

contractor will be held fully responsible for such unauthorized work, including the performance of all corrective measures required by the Architect.

5. Quantities for adjustment shall be calculated by a registered Professional Engineer or Surveyor retained by the Contractor, as agreed to by the Architect. Profiles of rock, work sheets, plans and method of calculation shall be submitted to Architect for approval.
6. Excavations of materials beyond the payment lines shall be at the expense of the Contractor.

F. Methods of Measurement of Ledge Excavation

1. The volume of each excavation shall be measured to the nearest cubic yard.
2. Solid boulders in original stratification will be measured to the 1/2 cubic yard.
3. Excavation outside the specified lines, whether due to slides or other causes, or made for any reason will not be paid for. The contractor at his own expense shall remove any material sliding into the excavation.
4. A trench shall be defined as an excavation of any depth where the width is less than twice the depth and the width is less than ten feet.
5. Basis of payment: The Base Bid assumes cubic yards of rock excavation as listed in subparagraph 1.12 A above. The Unit Price per cubic yard for excavation shall include the cost of furnishing all labor, materials, and equipment necessary to complete the work, including shoring, sheeting, and bracing required by the State or local codes, establishment of design subgrades, and all mark-up for overhead and profit.
6. Carefully examine rock excavations for foundations and remove loose or shaken rock down to solid bearing; level the rock surface or shelve it to a slope not exceeding one inch per foot, or as directed, leaving no undrained pockets in the surface.

1.17 LAYOUT AND GRADES

A. The Contractor is responsible for establishing vertical and horizontal control for the work and shall establish permanent benchmarks and replace as directed any, which are destroyed or disturbed. The Contractor shall maintain sufficient reference points at all times during construction to properly perform site grading. The existing survey benchmark shall be protected throughout the construction project.

B. Finished grades, contours, and elevations indicated on the Drawings describe final surface elevation for completed construction. The words “finished grade” as used herein shall mean final grade elevations indicated on the Drawings. Spot elevations shall govern over proposed contours. Where not otherwise indicated, project site areas shall be given uniform slope between points and existing established grades.

1.18 QUALITY ASSURANCE

A. Pre-Excavation Conference: Conduct conference at Project Site to comply with requirement in Section “Project Coordination”.

1. Before commencing earthwork, meet with representatives of the governing authorities, Owner, Architect, Civil Engineer, Geotechnical Engineer, consultants, independent testing agency, and other concerned entities. Review earthwork procedures and responsibilities including testing and inspection procedures and requirements. Notify participants at least 3 working days prior to convening conference. Record discussions and agreements and furnish a copy to each participant.

B. Testing: Compaction tests will be required by the Owner and will be paid for by the owner. No specific testing schedule has been established at this time. If tests indicate that density requirement have not been achieved, the contractor will continue compacting the tested material. All retesting is these areas shall be paid for by the contractor.

C. Density and Compaction Testing: The contractor is responsible to schedule compaction tests and allow adequate time for the proper execution of said tests.

D. The Owner's Testing Agency will perform water content, gradation tests on onsite and processed materials, and compaction tests at a frequency and at locations as required. The results of these tests will be submitted to the Architect, and a copy submitted to the Contractor, on a timely basis so that the Contractor can take such action as is required to remedy the indicated deficiencies.

E. Field inspection and testing may be performed by a Geotechnical or Civil Engineer at the Owner's expense to supplement the Contractor's Quality Control testing. Classification of all materials will be made by the Geotechnical Engineer whose decision shall be final and binding on the Contractor.

F. The Contractor shall be responsible for managing and tracking all materials excavated and placed in stockpiles for testing.

G. Comply with governing EPA notification regulations before beginning dewatering. Comply with hauling and disposal regulations of authorities having jurisdiction.

H. The Contractor is responsible for the adequacy of the dewatering systems.

1. The dewatering systems shall be capable of effectively reducing the hydrostatic pressure and lowering the groundwater levels to a minimum of 2 feet below excavation bottom unless otherwise directed by the Designer so that all excavation bottoms are firm and dry.
2. The dewatering system shall be capable of maintaining a dry and stable subgrade until the structures, pipes, and appurtenance to be built therein have been completed to the extent that they will not be floated or otherwise damaged.
3. The dewatering system and excavation support shall be designed so that the lowering of the groundwater level outside the excavation does not adversely affect adjacent structures, utilities, or other improvements.

I. The Owner will perform in place density tests in accordance with ASTM D2922 or D3017 as the Work progresses, to determine the degree of compaction. Any corrective work required as a result of such tests, such as additional compaction, or a decrease in the thickness of layers, shall be performed by the Contractor at no additional expense to Owner. In place, density testing shall be made at the Contractor's expense by a qualified geotechnical testing laboratory.

J. The Designer's duties do not include the supervision or direction of the actual work by the Contractor, his employees or agents. Neither the presence of the Designer nor any observation and testing by the Geotechnical Engineer shall excuse the Contractor from defects discovered in his Work at that time or subsequent to the testing.

K. Contractor shall assist the Owner's Testing Laboratory in performing in-place density testing at a minimum frequency of one test per lift but no less than one test per 200 cubic yards of

material placed in any one lift. Compaction testing will be performed in accordance with ASTM D1557, D2922, and D3017.

L. Subgrades shall be approved for compactness and material composition prior to placing subsequent lifts. If inspections indicate Work does not meet specified requirements, the work shall be removed, replaced, and compacted at no additional cost to Owner.

1.19 REGULATORY REQUIREMENTS

A. Comply with the Safety and Health regulations of the U.S. Department of Labor set forth in 29 CFR, Part 1926, and to the Massachusetts Department of Labor and Industries, Division of Industrial Safety “Rules and Regulations for the Prevention of Accidents in Construction Operations (454 CMR 10.0 et seq.). Contractors shall be familiar with the requirements of these regulations.

1. All excavations shall comply with the requirements of OSHA excavation safety standards (29 CFR Part 1926.650 Subpart P), State, and local requirements. Where conflict between OSHA, State, and local regulations exist, the most stringent requirements shall apply.

B. Comply with governing EPA notification regulations before, during, and upon completion of dewatering. Comply with hauling and disposal regulations of authorities having jurisdiction.

C. Comply with all rules, regulations, laws, and ordinances of the municipality, the Commonwealth of Massachusetts, and other authorities having jurisdiction over the project site or work. All labor, materials, equipment, and services necessary to make the work comply with requirements shall be provided by the Contractor without additional cost to the Owner.

D. The Contractor shall obtain and pay for all permits and licenses required to complete the work specified herein and indicated on the Contract Drawings.

E. The Contractor shall not close or obstruct any street, sidewalk, or passageway without written permission from authorities having jurisdiction unless otherwise indicated on the Contract Drawings. The Contractor shall conduct his operations as to minimize interference with the use of roads, driveways, or other facilities near enough to the work to be affected by the work.

F. The Contractor shall notify “Dig Safe” at 1-888-DIG-SAFE prior to commencing any excavation work.

G. The Contractor shall provide police details when working in roadways as required by local jurisdictional authorities. The Contractor shall pay for any and all details.

1.20 EXAMINATION OF SITE AND DOCUMENTS

A. It is hereby understood that the Contractor has carefully examined the site and all conditions affecting work under this Section. No claim for additional costs will be allowed because of a lack of knowledge of existing conditions as indicated in the Contract Documents, or obvious from observation of the site.

B. Plans, surveys, measurements, and dimensions under which the work is to be performed are believed to be correct, but the Contractor shall have examined them for himself during the bidding period and formed his own conclusions as to the full requirements of the work involved.

1.21 PROTECTION OF EXISTING CONDTIONS

A. All work shall be executed in such a manner as to prevent any damage to existing buildings, streets, curbs, paving, service utility lines, structures and adjoining property.

B. Locate and mark underground utilities to remain in service before beginning the work. Protect all existing utilities to remain in service during operations. Do not interrupt existing utilities except when authorized in writing by authorities have jurisdiction unless otherwise indicated on the Contract Drawings.

C. When an active utility line is exposed during construction its location and elevation shall be recorded on the Record Drawings by the Contractor and both the Engineer and the Utility Owner shall be notified in writing. Active utilities existing on the site shall be carefully protected from damage or relocated as required by the work.

D. Inactive or abandoned utilities encountered during construction operations shall be removed, plugged, capped or filled. The location of such utilities shall be recorded on the Record Drawings.

E. Provide barricades, fences, lights, signs, and all other safety devices required to protect the public against injury.

F. In case of any damage or injury caused in the performance of the work the Contractor shall, at his own expense make good such damage or injury to the satisfaction of, and without cost to, the Owner. Existing streets, sidewalks and curbs damaged during the project work shall be repaired or replaced to their condition prior to commencement of Earth Moving operations.

G. Acceptance of any of the Contractor's plans, design calculations and methods of construction by the Designer shall not relieve the Contractor of the responsibility for the adequacy of the excavation lateral support system; preventing damage to existing or new structures, utilities and streets adjacent to excavations; the safety of persons working within excavated areas and the public at large; and excavation dewatering.

1.22 DISPOSAL

A. All excess and unsuitable excavated soil shall be removed from the site and legally disposed offsite by the Contractor at no additional cost to the Owner.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.

B. Fill material shall be free from frost/ice and snow, rocks with a diameter greater than 2/3 of the loose lift thickness as specified herein, and foreign matter, such as construction debris, asphalt, trash, wood, roots, leaves, sod, and organic matter. All fill material shall be maintained by the contractor at suitable moisture contents for proper placement and compaction as specified herein.

C. Offsite pulverized pavement and crushed concrete are not acceptable for fill material. On-site pulverized pavement and crushed concrete that meets one of the gradation requirements specified herein can be used as backfill.

D. Fill material shall be obtained from required onsite cut to the extent suitable material is available, and off-site to the extent suitable material is not available from onsite cuts.

E. Fill material below the roadway pavement section (pavement and gravel borrow material) shall be sieved and the sieve analysis reviewed by the design team prior to installation. Placement of the material shall be in six (6) inch lifts and compacted to 95% relative density.

F. Onsite material for use in compacted fill shall be natural inorganic granular soil taken from areas of cut after removal of pavement, topsoil, or other unsuitable materials. Onsite materials should be tested for compliance with the specifications before placement.

G. Ordinary Fill shall be well-graded, natural inorganic soil with a plasticity index of less than 6 and with no stone greater than 6 inches maximum dimension. The materials shall be free of trash, ice, snow, tree stumps, roots, and other organic and deleterious materials. It shall be free of materials subject to decay, or other materials that will corrode piping or metals. Soil finer than the No. 200 sieve shall be non-plastic Ordinary Fill shall have a maximum dry density from a laboratory compaction tests of not less than 110 pounds per cubic foot. It shall be of such a nature and character that it can be compacted to the specified densities. Topsoil shall not be considered Ordinary Fill. Existing available fill materials from onsite excavations may be reused as Ordinary Fill if it meets the above requirements and the gradation requirements. It shall be graded within the following limits:

U. S. Standard Sieve Size	Percent Finer by Weight
6 inch	100
1 inch	50-100
No. 4	20-100
No. 20	10-70
No. 60	5-45
No. 200	0-20

H. Gravel Borrow: Gravel borrow shall meet the requirements of MassDOT M1.03.0, Type B. It shall be an inert, hard, durable sand and gravel or stone soil obtained from an offsite commercial source. It shall be free of ice, snow, roots, sod, rubbish, oil, hazardous material, and other deleterious or organic matter. It shall be graded within the following limits:

U. S. Standard Sieve Size	Percent Finer by Weight
3 inch	100
½ inch	50-85
No. 4	40-75
No. 50	8-28
No. 200	0-10*
*7% max. under sidewalks	

I. Structural Fill shall consist of inert, hard, durable sand and gravel, free from ice and snow, organic matter, clay, surface coatings, and deleterious materials, and shall have a plasticity

index of less than 6. Structural fill shall be placed in 9-inch loose lifts and shall conform to the following gradation requirements:

U. S. Standard Sieve Size	Percent Finer by Weight
3 inches	100
1 ½ inches	80-100
½ inches	50-100
No. 4	30-85
No. 20	15-60
No. 60	5-35
No. 200	0-10*

*7% max. under sidewalks

The fines content of imported Structural Fill shall be less than 10 percent as shown in the table above. The fines content of Structural Fill processed onsite shall be less than 12 percent, except in the top 12 inches immediately beneath the slab or the under-slab drainage system where it shall be less than 10 percent.

J. Select Structural Fill shall meet the requirements of Structural Fill except that the percent passing the No. 200 sieve shall be less than 7 percent.

K. ¾" Crushed Stone: ¾" crushed stone shall meet the requirements of MassDOT M2.01.4. It shall consist of durable crushed rock or crushed gravel stone, free of ice, snow, sand, silt, clay, loam, shale, or other deleterious or organic matter. It shall be graded within the following limits:

U. S. Standard Sieve Size	Percent Finer by Weight
1 inch	100
¾ inch	90-100
½ inch	10-50
3/8 inch	0-20
No. 4	0-5

L. 1-1/2" Crushed Stone: 1-1/2" crushed stone shall meet the requirements of MassDOT M2.01.1. It shall consist of durable crushed rock or crushed gravel stone, free of ice, snow, sand, silt, clay, loam, shale, or other deleterious or organic matter. It shall be graded within the following limits:

U. S. Standard Sieve Size	Percent Finer by Weight
2 inch	100
1-1/2 inch	95-100
1 inch	35-70
¾ inch	0-25

M. Crushed stone required around utility piping, detention/recharge systems, other stormwater infrastructure, underslab drain piping and radon mitigation piping within the building, and building perimeter drain piping shall meet the gradation requirements of Sections K and L above. Onsite material may be processed and crushed to meet those requirements.

N. Dense Graded Crushed Stone: Dense graded crushed stone shall meet the requirements of MassDOT M2.01.7. It shall consist of a mixture of crusher-run aggregate of crushed stone mixed with natural sand and gravel soil obtained from an offsite commercial source. It shall

be free of ice, snow, roots, sod, rubbish, soil, hazardous material, and other deleterious or organic matter. It shall be graded within the following limits:

U. S. Standard Sieve Size	Percent Finer by Weight
2-inch	100
1-½ inch	70-100
¾ inch	50-85
No. 4	30-55
No. 40	8-24
No. 200	3-10*

*7% max. under sidewalks

O. Sand: Sand shall meet the requirements of MassDOT M1.04.1. It shall consist of clean inert, hard, durable grains of quartz or other hard durable rock, free from clay, organics, surface coatings, or other deleterious or organic matter. It shall be graded within the following limits:

U. S. Standard Sieve Size	Percent Finer by Weight
½ inch	100
3/8 inch	85-100
No. 4	60-100
No. 16	35-80
No. 50	10-55
No. 100	2-10

P. Dumped Riprap: Stone used for dumped riprap shall be hard, durable, angular in shape stones, resistant to weathering and shall meet the gradation requirement specified. Neither breadth nor thickness of a single stone should be less than one-third its length. Rounded stone or boulders will not be accepted unless authorized by the Engineer. Each load of riprap shall be reasonably well graded from the smallest to the maximum size specified. Stone shall be free from overburden, spoil, shale, and organic material and shall conform to the following gradation with no more than 5% by weight passing a 3-inch sieve:

Weight of Stone (lbs.)	Percent Finer by Weight
400	100
300	50
200	30
25	10

Q. Stone for Pipe Ends: Stone for pipe ends shall be sound, curable rock which is angular in shape. Rounded stones, boulders, sandstone or similar stone or relatively thin slabs will not be acceptable. Each stone shall weigh not less than 50 pounds not more than 125 pounds and at least 75% of the volume shall consist of stones weighing not less than 75 pounds each. The remainder of the stones shall be so graded that when placed with the larger stones the entire mass will be compact.

R. Controlled Density Fill (CDF) shall be a cement concrete backfill material that flows like a liquid, supports like a solid when cured, and levels without tamping or vibrating to reach 100 percent compaction. CDF shall meet the requirements of MassDOT Specifications M4.08.00 for Type 1E (Very Flowable, Excavatable) or type 2E (Flowable, Excavatable) CDF. The mix

formulation will be submitted to the Designer for review prior to placement of the material in the project.

S. Reuse of Excavated Rock: Excavated onsite rock materials processed by the Contractor meeting the gradation limits for ¾" Crushed Stone, 1-½" Crushed Stone, Dense Graded Crushed Stone, and Stone for Pipe Ends contained herein may be segregated and reused as approved by the Owner.

2.2 UNSUITABLE MATERIALS

A. Unsuitable material shall be material having at least one of the following properties:

1. Material with a maximum unit dry weight per cubic foot less than 100 lbs., as determined by ASTM D1557.
2. Material containing greater than 3% organic matter by weight, topsoil, organic silt, peat, construction debris, roots and stumps.
3. Material which has a Liquid Limit greater than 55 when tested in accordance with ASTM D 4318.
4. Materials that do not meet one of the gradation specifications in this section.
5. Material classified as unsuitable by the Geotechnical Engineer.
6. Unsuitable material shall be disposed of off-site as directed by the Architect.
7. Materials that are unstable as a result of inadequate construction dewatering, excessive subgrade disturbance, or other means and methods used by the Contractor are not considered unsuitable materials.
8. Onsite processed material that is not well graded and that exhibits honeycombing during placement and compaction.

2.3 GEOTEXTILES

A. Subsurface Drainage Geotextile: Nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefins or polyesters; complying with AASHTO M 288 and the following, measured per test methods referenced:

1. Survivability: Class 2; AASHTO M 288.
2. Elongation: 50% minimum; ASTM D 4632
3. Grab Tensile Strength: 160 lbs; ASTM D 4632.
4. Trapezoid Tear Strength: 60 lbs; ASTM D 4533.
5. CBR Puncture Strength: 410 lbs; ASTM D 6241
6. Apparent Opening Size: No. 70 sieve maximum; ASTM D 4751.
7. Permittivity: 1.50 sec-1 minimum; ASTM D 4491
8. UV Stability: 70% after 500 hours' exposure; ASTM D 4355.

B. Separation Geotextile: Woven geotextile fabric, manufactured for separation applications, made from polyolefins or polyesters; complying with AASHTO M 288 and the following, measured per test methods referenced:

1. Survivability: Class 1; AASHTO M 288.
2. Elongation: 15% maximum; ASTM D 4632
3. Grab Tensile Strength: 315 lbs; ASTM D 4632.
4. Trapezoidal Tear Strength: 120 lbs; ASTM D 4533.
5. Puncture Strength: 1,000 lbs; ASTM D 6241.
6. Apparent Opening Size: No. 40 sieve, maximum; ASTM D 4751.
7. Permittivity: 0.05 sec-1 minimum; ASTM D 4491.

8. UV Stability: 70% after 500 hours' exposure; ASTM D 4355.

2.4 ACCESSORIES

A. Detectable Underground Warning Tapes: Acid and alkali-resistant polyethylene plastic film warning tape, 6-inches wide by 4-mils minimum thickness, with continuously printed caption in black letters "CAUTION - xxxxx LINE BURIED BELOW." The text and color of the tape shall be as shown in the table below. The tape shall have a metallic core encased in a protective jacket for corrosion protection and be detectable by a metal detector when the tape is buried up to 2.5-feet deep.

Color	Utility
Safety Red	Electric
High Visibility Safety Yellow	Gas, Oil, Steam
Safety Alert Orange	Telephone, Communications, Cable Television
Safety Precaution Blue	Water System, Irrigation
Safety Green	Sanitary Sewer, Storm Sewer
White	Proposed Excavation

2.5 USES OF MATERIALS

A. Fill materials listed in Paragraph 2.1 above shall be utilized as follows and as otherwise indicated on the Drawings, specified or directed.

B. Gravel Borrow:

1. As fill (base course) below the Dense Graded Crushed Stone placed immediately beneath concrete and asphalt pavements as shown on the Contract Drawings.
2. Bedding for ductile iron drain, water, and sewer piping.

C. Dense Graded Crushed Stone:

1. As base course soils immediately below concrete and asphalt pavement as shown on the Contract Drawings.

D. ¾” and 1-½” Crushed Stone:

1. Base for drain manholes, catch basins, sewer manholes, and utility structures.
2. Bedding for drain pipe and sewer pipe.
3. Around perforated drain lines.
4. To stabilize wet subgrade conditions.
5. Elsewhere as shown on the Drawings or specified herein.
6. To aid in dewatering.

E. Sand:

1. Bedding for drain, water, sewer, and other utility piping.
2. Elsewhere as shown on the Drawings or specified herein.

F. Structural Fill

1. Within the proposed building footprint.
2. Under site retaining walls.
3. Backfill with the 3 feet of the back face of site retaining walls.

G. Ordinary Fill:

1. For general site fill outside of the proposed building footprint, concrete, and below sub-base layer of asphalt and concrete pavement areas.
2. Trench backfill material.
3. In fill slopes.
4. Elsewhere as shown on the Drawings or specified herein.

H. Geotextiles:

1. Subsurface non-woven Drainage Geotextile shall fully wrap 3-4-inch Crushed Stone.
2. Use to prevent soil intrusion into drains and/or to assist in stabilizing soil subgrades prior to placement of fill materials.
3. Subsurface woven separation geotextile as separation material between crushed stone and gravel borrow base materials below concrete and asphalt pavement as shown on the Contract Drawings.
4. Where indicated or shown in the Contract Drawings.
5. A geotextile fabric shall not be used between crushed stone and soil fill material at the base of retaining walls. Where separation between crushed stone and soil fill material is required, the crushed stone should be choked by means of a soil filter.

I. Controlled Density Fill (CDF):

1. CDF shall be used as shown on the Contract Drawings.
2. CDF shall be used if directed by the DESIGNER as fill at the limits of the excavation areas.

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

A. The Contract Drawings indicate the proposed finish alignment, elevation, and grade of the work. Establish the line and grade in close conformity with the Contract Drawings. The Owner's Representative, however, may make minor adjustments in the field as necessary due to conditions encountered.

B. The Contractor is responsible for establishing construction phasing, means, and methods and interim grading and temporary conditions required to attain the finish product required by the Contract Documents. The Contractor is responsible for all construction, protection, movement, and maintenance of stockpiles. Establish and maintain suitable benchmarks and grade control to accurately perform the work.

C. Protect all benchmarks, monuments, and property boundary pins. Replace if destroyed by contractor's operation.

D. All excavation shall be performed in the dry. Excavation and dewatering shall be accomplished by methods, which preserve the undisturbed state of the subgrade soils.

E. No excavation will be permitted below a line drawn downwards at 2 horizontal to 1 vertical from the underside of the closest edge of any in-place footing or utility at a higher elevation without providing adequate sheeting and bracing to prevent movement of the in-place footing or utility.

F. When excavations have reached the prescribed depths, the condition of the bottom of the trench or hole shall be inspected by the Owner's Representative. After inspection, the Contractor will receive approval to proceed if conditions meet project requirements.

G. No excavated material shall be deposited or stockpiled at any time to endanger portions of new or existing structures, either by direct pressure or indirectly by overloading banks contiguous to the operation. Material, if stockpiled, shall be stored so as not to interfere with the established sequence of the construction. If there is not sufficient area available for stockpiling within the limits of the project, the Contractor will be required to furnish his own area for stockpiling.

H. When the plans require excavation in areas in close proximity to existing buildings, roads, structures and utilities it shall be the responsibility of the Contractor at his expense to use satisfactory means and methods to protect and maintain the stability of such roads, and structures located immediately adjacent to but outside the limits of excavations.

I. Temporary ditches shall be made as needed to drain off surface water to avoid damaged to areas of cut or fill. Such ditches shall be maintained as required for efficient operations, at no additional cost to the Owner.

J. Provide shoring, sheeting, and/or bracing at excavations, as required, to assure complete safety against collapse of earth at the side of excavations. Provide shoring of public utility lines where exposed in the excavations in accordance with rules and regulations of the local authorities, as no additional cost to the Owner.

K. Cut and remove trees, remove stumps and brush. Legally dispose of off-site. Wood wastes may be chipped and shredded onsite and reused onsite with permission of the Architect.

L. Strip topsoil to its full depth within the Contract limits. Remove the subsoil, roots, stumps and other deleterious matter entirely under footings, slabs, and paved areas. Where the subsoil extends to depths greater than 18 inches beneath the bottom of the proposed pavement, the subsoil deeper than 18 inches beneath the bottom of the proposed pavement may remain in place provided that it is improved in accordance with the recommendations in Section 4.1. The removal of the topsoil and subsoil should laterally extend 5 feet outside the limits of improvement areas.

M. Sump pumps shall be surrounded by suitable filter media to minimize the fines removed during pumping. Pumped groundwater and surface water runoff shall be pumped to a settling basin to remove suspended solids prior to discharge.

N. Discharge of pumped water, either surface water runoff or groundwater, shall be in compliance with discharge criteria contained in permits issued by governing agencies, and all legal requirements and regulations. All permits shall be obtained by the Contractor.

O. The crushed stone placed in the sump pump pits should be wrapped in a geotextile fabric. Where a geotextile fabric is not used, the crushed stone should be entirely removed after

the sump pump is no longer in use and the sump pump pit should be restored with suitable backfill.

3.2 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations.

B. Preparation of subgrade for earthwork operations including removal of vegetation, topsoil, debris, obstructions, and deleterious materials from ground surface is specified in Section 311000 - SITE CLEARING.

C. Protect and maintain erosion and sedimentation controls, which are specified in Section 312500 – EROSION AND SEDIMENTATION CONTROLS, during earthwork operations.

D. Provide protective insulating materials to protect subgrades and foundation soils against freezing temperatures or frost.

3.3 DEWATERING

A. Provide Dewatering as required to maintain dry excavations.

B. Prevent surface water and groundwater from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.

C. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.

1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.
2. Install a dewatering system to keep subgrades dry and convey groundwater away from excavations. Maintain until dewatering is no longer required.
3. Where soil has been softened or eroded by flooding, equipment, traffic or placement of fill or concrete during unfavorable weather or such other conditions, it shall be removed and replaced by the Contractor with suitable material and at the Contractor’s expense. The necessity and extent of such removals shall be determined by the Designer.

D. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by dewatering operations.

E. Monitor dewatering systems continuously.

F. Install dewatering system utilizing wells, well points, or similar methods complete with pump equipment, standby power and pumps, filter material gradation, valves, appurtenances, water disposal, and surface-water controls.

1. Space well points or wells at intervals required to provide sufficient dewatering.
2. Use filters or other means to prevent pumping of fine sands or silts from the subsurface.

G. Before excavating below ground-water level, place system into operation to lower water to specified levels. Operate system continuously until drains, sewers, and structures have been constructed and fill materials have been placed or until dewatering is no longer required.

H. Provide an adequate system to lower and control groundwater to permit excavation, construction of structures, and placement of fill materials on dry subgrades. Install sufficient dewatering equipment to drain water-bearing strata above and below bottom of foundations, drains, sewers, and other excavations.

1. Do not permit open-sump pumping that leads to loss of fines, soil piping, subgrade softening, and slope instability.

I. Reduce hydrostatic head in water-bearing strata below subgrade elevations of foundations, drains, sewers, and other excavations.

1. Maintain piezometric water level a minimum of 12 inches below surface of excavation.

J. Dispose of water removed by dewatering in a manner that avoids endangering public health, property, and portions of work under construction or completed. Dispose of water and sediment in a manner that avoids inconvenience to others. Provide sumps, sedimentation tanks, and other flow-control devices as required by authorities having jurisdiction.

K. Provide standby equipment on site, installed and available for immediate operation, to maintain dewatering on continuous basis if any part of system becomes inadequate or fails. If dewatering requirements are not satisfied due to inadequacy or failure of dewatering system, restore damaged structures and foundation soils at no additional expense to the Owner.

1. Remove dewatering system from Project site on completion of dewatering. Plug or fill well holes with sand or cut off and cap wells a minimum of 36 inches below overlying construction.

L. Damages: Promptly repair damages to adjacent facilities caused by dewatering operations.

3.4 EXCAVATION SUPPORT AND PROTECTION

A. Work shall not be started until all materials and equipment necessary for the construction are either on the site of the work or satisfactorily available for immediate use as required.

B. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards that could develop during excavation support and protection system operations.

1. Shore, support and protect utilities encountered.

C. Install excavation support and protection systems to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from the Owner’s Representative and authorities having jurisdiction. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

D. Locate excavation support and protection systems clear of permanent construction so that forming and finishing of concrete surfaces or installation of improvements is not impeded.

E. The excavation support and protection systems shall be securely and satisfactorily braced to withstand all pressures to which it may be subjected and be sufficiently tight to minimize lowering of the groundwater level outside the excavation.

F. Monitor, including by means of DMPs, excavation support and protection systems daily during excavation progress and for as long as excavation remains open. Promptly correct bulges, breakage, or other evidence of movement to ensure that excavation support and protection systems remain stable.

G. Promptly repair damages to adjacent facilities caused by installing excavation support and protection systems.

H. Responsibility for the satisfactory construction and maintenance of the excavation support system, complete in place, shall rest with the Contractor. Any work done, including incidental construction, which is not acceptable for the intended purposed shall be either repaired or removed and reconstructed by the Contractor at his expense.

I. Remove excavation support and protection systems when construction has progressed sufficiently to support excavation and bare soil and hydrostatic pressures. Remove in stages to avoid disturbing underlying soils or damaging structures, pavements, facilities, and utilities.

1. Remove excavation support and protection systems to a minimum depth of 48 inches below overlaying construction and abandon remainder.
2. Fill voids immediately with approved backfill compacted to density specified herein.
3. Repair or replace, as approved by Owner's Representative, adjacent work damaged or displaced by the installation, performance, and removal of the excavation support and protection systems.

3.5 EXCAVATION, GENERAL

A. Unclassified Excavation: Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions.

1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.
2. Remove rock to lines and grades indicated to permit installation of permanent construction without exceeding the following dimensions:

a. 24 inches outside of concrete forms.
b. 6 inches outside of minimum required dimensions of concrete cast against grade.
c. 6 inches beneath pipe in trenches, and the greater of 24 inches wider than pipe or 42 inches wide.

B. Provide sheeting, shoring and bracing to complete and protect all excavated areas, are required for safety and compliance with OSHA. Cost for sheeting, shoring and bracing shall be included as a part of the contract price for completing the work and Owner shall make no separate payment for this work.

C. Perform excavation work in accordance with all applicable Federal, State, and Local regulations regarding safe excavation work.

D. Excavation in the area of existing utilities. Expose utilities by hand or other excavation methods that will prevent damage. Required excavation near electric, gas, water lines, and fiber-optic telecommunication lines shall be hand dug within 3 feet of the lines.

E. Do not excavate to full depths when freezing temperatures may be expected unless subgrades are protected from freezing.

3.6 EXCAVATION FOR STRUCTURES

A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.

1. Excavation for Underground Tanks, Manholes, Basins, Mechanical and/or Electrical Utility Structures, Drainage and Sewer Systems, Infiltration Systems, and Utility Structures: Excavate to elevations and dimensions indicated within a tolerance of plus or minus 1 inch. Do not disturb bottom of excavations intended as bearing surfaces.

3.7 EXCAVATION FOR WALKS AND PAVEMENTS

A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

3.8 EXCAVATION FOR UTILITY TRENCHES

A. Excavate trenches to indicated gradients, lines, depths, and elevations.

1. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.

B. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to 12 inches higher than top of pipe or conduit, unless otherwise indicated.

1. Clearance: 12 inches each side of pipe or conduit.

C. Trench Bottoms: Excavate and shape trench bottoms to provide uniform bearing and support of pipes and conduit. Shape subgrade to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits. Remove projecting stones and sharp objects along trench subgrade.

1. For pipes and conduit less than 6 inches in nominal diameter and flat-bottomed, multiple-duct conduit units, hand-excavate trench bottoms and support pipe and conduit on an undisturbed subgrade.
2. For pipes and conduit 6 inches or larger in nominal diameter, shape bottom of trench to support bottom 90 degrees of pipe circumference. Fill depressions with tamped sand backfill.
3. Excavate trenches 6 inches deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.

3.9 SUBGRADE PREPARATION AND INSPECTION

A. The subgrade shall be shaped to line, grade, and cross section, and be thoroughly compacted in accordance with the requirements of paragraph 3.03. This operation shall include any required reshaping and wetting to obtain proper compaction. All soft or otherwise unsuitable material shall be removed and replaced with suitable material from excavation or borrow. The resulting area, and all other low sections, holes, or depressions shall be brought to the required grade with accepted material and the entire subgrade shaped to

line, grade and cross section and thoroughly compacted. The geotechnical engineer may at his discretion request proof-rolling using a loaded rubber tire truck.

B. Before surface or base materials are spread, the subgrade shall be shaped to an accurate and true surface conforming to the line and grades indicated on the Contract Drawings. All surface irregularities shall be filled with suitable material or removed and such areas re-compacted until the surface is properly shaped and properly compacted. A tolerance of 3/8-inch in paved areas and 1/2-inch in non-paved areas above or below the finished subgrade elevation will be allowed provided that this dimension above or below grade is not maintained for a distance longer than 50-feet and that the required crown is maintained in the subgrade. Any portion, which is not accessible to a roller, shall be thoroughly compacted by other mechanical or manual methods.

C. Notify the Owner's Representative when excavations have reached required subgrade.

D. If the Owner's Representative, Geotechnical Engineer, and/or the Designer determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.

E. Proof-roll granular subgrade below structures and pavements with heavy vibrating drum roller to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

1. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph.
2. Proof-roll with approved equipment weighing not less than 15 tons.
3. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Designer, and replace with compacted backfill or fill as directed.

F. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by the Geotechnical Engineer and/or the Designer, without additional compensation.

G. Protect all subgrades from disturbance.

1. Place Gravel Borrow or Crushed Stone wrapped in non-woven geotextile over clayey, silty or wet footing subgrades. Fill shall not be placed in standing water.
2. Grade around prepared subgrade areas to direct stormwater runoff away from the work area.
3. Protect subgrades from frost at all times during construction. Fill should not be placed over frozen soil.

3.10 UNAUTHORIZED EXCAVATION

A. Fill unauthorized excavations under site improvement construction or utility pipe as directed by Designer. Lean concrete fill, with 28-day compressive strength of 2500 psi may be used when approved by Designer.

3.11 STORAGE OF SOIL MATERIALS

A. Stockpile borrow soil materials (from offsite sources) and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.

1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.
2. Stockpile soil materials in a location, acceptable to the Owner's Representative, that will preclude having to relocate stockpiled soil materials that would otherwise delay or impact the Work.

3.12 BACKFILL

A. Place and compact backfill in excavations promptly, but not before completing the following:

1. Construction below finish grade including, where applicable, subdrainage, dampproofing, waterproofing, and perimeter insulation.
2. Surveying locations of underground utilities for Record Documents.
3. Testing and inspecting underground utilities.
4. Removing concrete formwork.
5. Removing trash and debris.
6. Removing temporary shoring and bracing, and sheeting.
7. Installing permanent or temporary horizontal bracing on horizontally supported walls.

B. Place backfill on previously placed and compacted fill and/or subgrades free of mud, frost, snow, or ice.

C. Excavated onsite natural soils may be used as Ordinary Fill, provided the material can be placed and compacted as required herein and at the approval of the Designer.

D. The Contractor shall not commence backfilling operations without approval of the Owner's Representative and/or the Designer.

E. The Contractor shall maintain a dry and firm subgrade throughout construction. Dewatering shall be performed as needed at the Contractor's expense.

F. The Contractor shall strip the existing subgrade of any vegetation, topsoil, organics, debris, or other unsuitable materials. The subgrade shall be proof compacted using a vibratory roller to treat any loose or disturbed areas and to provide a dense uniform surface.

G. After the subgrade has been prepared, fill material shall be placed and built-up in successive layers until the required elevations are reached. No fill shall be placed on a frozen surface, nor shall snow, ice, or other frozen materials be included in fill. Wet materials containing moisture in excess of the amount necessary for satisfactory placement or compaction shall not be used.

H. All fills shall be placed in horizontal layers. Fill shall not be placed following the natural contours of the ground. Fill shall be placed starting in the lowest areas working up to finish grades in horizontal layers in the manner specified herein. Each layer of fill shall be benched into the existing slope in order to avoid the formation of a shear plane.

I. All fill shall be brought up in essentially level lifts and shall be placed in levels by standard methods. Layers of fill outside of utility trenches shall not exceed nine (9) inches in uncompacted thickness before compaction, unless otherwise specified, or as required for proper subgrade stabilization.

J. Filling operations shall continue until the fill has been brought up to the finished slopes, lines, and grades making proper allowances for thickness of the overlying topsoil.

K. The entire surface of the work shall be maintained free from ruts and in the condition that will permit construction equipment to travel over any section readily. The top surface of each layer shall be made level or slightly sloped toward the center of the filled area.

L. Backfilling shall not be performed when weather conditions or the conditions of the materials are such that, in the opinion of the Geotechnical Engineer or the Designer, work cannot be performed satisfactorily.

M. Backfill Material: Unless otherwise specified or directed, material used for filling and backfilling shall meet the material requirements specified herein. In general, the material used for backfilling utility trench excavations shall be material removed from the excavations provided that the reuse of these materials results in the required trench compaction and meets the requirements specified for Ordinary Fill. All backfill placed within the building limits shall be Structural Fill unless otherwise specified. In areas where the bottom of the excavation is in fine sand and silt, and is below the groundwater table, the first lift of backfill shall be 12 inches of 3/4-inch maximum crushed stone to provide a working mat and drainage layer. Place backfill to a maximum loose lift thickness of 12-inches. Maintain backfill material with a uniform moisture content, with no visible wet or dry streaking, between plus two percent and minus three percent of optimum moisture content. The final filled soil mass shall be as uniform as possible in lift thickness, moisture content, and effort required to compact soil mass.

3.13 BACKFILLING AGAINST STRUCTURES

A. Place backfill on subgrades free of mud, frost, snow, or ice.

B. Backfilling against masonry or concrete shall not be done until permitted by the Owner's Representative. The Contractor shall not place backfill against or on structures until they have attained sufficient strength to support the loads (including construction loads) to which they will be subjected, without distortion, cracking or other damage.

C. As soon as practicable after the structures are structurally adequate and other necessary work has been satisfactorily completed and approved, special leakage tests of the structures shall be made by the Contractor, as required by the Owner's Representative. After the satisfactory completion of leakage tests and the satisfactory completion of any other required work in connection with the structures, the backfilling around the structures shall proceed using suitable and approved excavation material.

D. Only hand-operated roller or plate compactors shall be used within a lateral distance of 5 feet of back of wall for walls less than 15 feet high and within 10 feet of back of wall for walls more than 15 feet high. The backfill material shall be compacted with a dynamic vibratory compactor weighing no more than 1000 pounds and imparting a minimum of no more than 8 kips of force to the subgrade.

E. The best of the backfill material shall be used for backfilling within 2-feet of the structure. Just prior to placing backfill, the areas shall be cleaned of all excess construction material and debris and the bottom of excavations shall be in a thoroughly compacted condition.

F. Symmetrical backfill loading shall be maintained. Special care shall be taken to prevent any wedging action or eccentric loading upon or against the structures. During backfilling operations, care shall be exercised that the equipment used will not overload the structures in passing over and compacting these fills. Except as otherwise specified or directed, backfill shall be placed in layers not more than 12 inches in loose depth and each layer of backfill

shall be compacted thoroughly and evenly using approved types of mechanical equipment. Each pass of the equipment shall cover the entire area of each layer of backfill.

G. In compacting and other operations, the Contractor shall conduct his operations in a manner to prevent damage to structures due to passage of heavy equipment over, or adjacent to, structures, and any damage thereto shall be made good by the Contractor at no additional expense to the Owner.

3.14 UTILITY TRENCH BACKFILL

A. Place backfill on subgrades free of mud, frost, snow, or ice.

B. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.

C. Backfill trenches excavated under footings and within 18 inches of bottom of footings with satisfactory soil; fill with concrete to elevation of bottom of footings. Concrete is specified in Section 033000 - CAST-IN-PLACE CONCRETE.

D. Provide 4-inch- thick, concrete-base slab support for piping or conduit less than 30 inches below surface of roadways. After installing and testing, completely encase piping or conduit in a minimum of 4 inches of concrete before backfilling or placing roadway subbase.

E. Place and compact initial backfill of subbase material free of particles larger than 1 inch in any dimension, to a height of 12 inches over the utility pipe or conduit.

1. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of utility piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.

F. Backfill voids with satisfactory soil while installing and removing shoring and bracing.

G. Backfill material shall be placed in maximum 6-inch lifts and mechanically competed as specified herein.

H. Place and compact final backfill of satisfactory soil to final subgrade elevation.

I. Refer to Document from Lord Associates dated 02/12/2018 or most current revised date, Published as Appendix C regarding the reuse of existing earthen material and required cover at areas. These requirements are limited to areas of increased exposure and are defined as all areas inside of the interior curb around the building and play areas, fields. Areas outside this ring the existing excavated materials can be used as backfill, subject to meeting grading and other requirements specified herein.

J. Install warning tape directly above utilities, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

K. Any trenches or excavations improperly backfilled or where settlement occurs shall be reopened, to the depth required for proper compaction, then refilled and compacted with the surface restored to the required grade and condition, at no additional expense to the Owner.

L. During filling and backfilling operations, pipelines will be checked by the Owner's Representative to determine whether any displacement of the pipe has occurred. If the observation

of the pipelines shows poor alignment, displaced pipe or any other defects they shall be remedied in a manner satisfactory to the Owner's Representative at no additional cost to the Owner.

3.15 SOIL FILL

A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.

B. Place and compact fill material in layers to required elevations as follows:

1. Under grass and planted areas, use satisfactory soil material.
2. Under walks and pavements, use satisfactory soil material.

C. Place soil fills on subgrades free of mud, frost, snow, or ice.

D. In freezing weather, a layer of fill shall not be left in an uncompacted state at the close of the day's operations. Prior to terminating work for the day, the final layer of compacted fill shall be rolled with a smooth wheeled roller to eliminate ridges of soil left by compaction equipment.

3.16 SOIL MOISTURE CONTROL

A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content.

1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.
2. Remove and replace or scarify and air dry otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.
3. In no case shall fill be placed over material that is frozen. Fill material shall not be placed, spread or rolled during unfavorable weather conditions. When work is interrupted by heavy rains, fill operations shall not be resumed until the moisture content and the density of the previously placed fill are as specified.
4. Fill that is too dry for proper compaction shall receive water uniformly applied over the surface of the loose layer. Sufficient water shall be added to allow compaction to the required density.

3.17 COMPACTION OF SOIL BACKFILLS AND FILLS

A. Place backfill and fill soil materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches in loose depth for material compacted by hand-operated tampers.

B. Place backfill and fill soil materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.

C. Compact soil materials to not less than the following percentages of maximum dry unit weight according to ASTM D 1557:

Area	ASTM Density Degree of Compaction
Structural Fill below footings	95%
Structural Fill below slabs	95%
Dense Graded Crushed Stone and Gravel Borrow for pavement and walkway base/subbase course	95%
Pavement and walkway subgrade where scarified	95%
Ordinary Fill below pavement and walkway subbase and in fill slopes	95%
Ordinary Fill for trench backfill - below pavements - below landscaped areas - below structures	 95% 92% 95%
All other areas	90%

1. Under structures and pavement, proof-compact existing subgrade. Compact each layer of backfill soil material at 95 percent of the soils' maximum dry density (per ASTM D 1557). Fill areas within the 1H:1V influence zone of foundations and retaining wall footings shall also be compacted to 95 percent of the soils' maximum dry density (per ASTM D 1557).
2. Under walkways, scarify and re-compact top 6 inches below subgrade to 95 percent of the soils' maximum dry density (per ASTM D 1557). Fill and base course material within 2 feet of the finished asphalt or concrete pavement grade shall be compacted to 95 percent of the soils' maximum dry density (per ASTM D 1557).
3. For utility trenches in paved areas, compact each layer of initial and final backfill soil material to at least 95 percent of the soils' maximum dry density (per ASTM D 1557).
4. For utility trenched in lawn or unpaved areas, compact each layer of backfill soil material to at least 92 percent of the soils' maximum dry density (per ASTM D 1557).
5. Under lawn or unpaved areas, scarify and re-compact top 6 inches below subgrade and compact each layer of backfill or fill soil material to at least 90 percent of the soils' maximum dry density (per ASTM D 1557).
6. Fill placed in the top 3 feet under natural and synthetic turf should be compacted per the requirements of the turf designer and the landscape architect.
7. Subsoil deeper than 18 inches beneath the bottom of the proposed pavement shall be improved by compacting the exposed surface with at least six (6) passes of a vibratory roller compactor imparting a dynamic effort of at least 40 kips.

D. In confined areas, place Crushed Stone in maximum 6-inch lifts and compact each lift with at least 4 passes of a vibratory plate compactor to a firm and unyielding surface. In open areas, place Crushed Stone in maximum 12-inch lifts and compact each lift with at least four passes of a vibratory drum roller with a minimum static weight of 10,000 pounds. Crushed stone fill shall be wrapped on all sides with non-woven filter fabric.

3.18 GRADING

A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.

1. Provide a smooth transition between adjacent existing grades and new grades.
2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.

B. Site Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:

1. Lawn or Unpaved Areas: Plus or minus 1 inch.
2. Walks: Plus or minus 1 inch.
3. Pavements: Plus or minus 1/2 inch.

3.19 SUBSURFACE DRAINAGE

A. Subdrainage Pipe: Specified in Division 2 Section "Subdrainage."

B. Subsurface Drain: Place subsurface drainage geotextile around perimeter of subdrainage trench. Place a 6-inch course of filter material on subsurface drainage geotextile to support subdrainage pipe. Encase subdrainage pipe in a minimum of 12 inches of filter material, placed in compacted layers 6 inches thick, and wrap in subsurface drainage geotextile, overlapping sides and ends at least 6 inches.

1. Compact each filter material layer to 85 percent of maximum dry unit weight according to ASTM D 1557.

C. Drainage Backfill: Place and compact filter material over subsurface drain, in width indicated, to within 12 inches of final subgrade, in compacted layers 6 inches thick. Overlay drainage backfill with 1 layer of subsurface drainage geotextile, overlapping sides and ends at least 6 inches.

1. Compact each filter material layer to 85 percent of maximum dry unit weight according to ASTM D 1557.
2. Place and compact impervious fill over drainage backfill in 6-inch-thick compacted layers to final subgrade.

3.20 SUBBASE AND BASE COURSES

A. Place subbase and base course on subgrades free of mud, frost, snow, or ice.

B. On prepared subgrade, place subbase and base course under pavements and walks as follows:

1. Install separation geotextile fabric on prepared subgrade, where indicated on the Contract Drawings, according to manufacturer's written instructions, overlapping sides, and ends.
2. Place base course material over subbase course under asphalt pavement.
3. Shape subbase and base course to required crown elevations and cross-slope grades.
4. Place subbase and base course 6 inches or less in compacted thickness in a single layer.

5. Place subbase and base course that exceeds 6 inches in compacted thickness in layers of equal thickness, with no compacted layer more than 6 inches thick or less than 3 inches thick.
6. Compact subbase and base course at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 95 percent of maximum dry unit weight according to ASTM D 1557.

C. Pavement Shoulders: Place shoulders along edges of subbase and base course to prevent lateral movement. Construct shoulders, at least 12 inches wide, of satisfactory soil materials and compact simultaneously with each subbase and base layer to not less than 95 percent of maximum dry unit weight according to ASTM D 1557.

3.21 DRAINAGE COURSE

A. Place drainage course on subgrades free of mud, frost, snow, or ice.

B. On prepared subgrade, place and compact drainage course under pavements, walkways and cast-in-place concrete slabs-on-grade as follows:

1. Install subdrainage geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides, and ends.
2. Compact each layer of drainage course to required cross sections and thicknesses to not less than 95 percent of maximum dry unit weight according to ASTM D 1557.

3.22 FIELD QUALITY CONTROL

A. Independent Testing Agency: Cooperate with the Independent Testing Agency engaged by the Owner for field quality control activities for the Work of this Section. Refer also to Section 014325 - TESTING AGENCY SERVICES.

B. Cooperate with field quality control personnel.

C. Additional inspections and retesting of materials which fail to comply with specified material and installation requirements shall be performed at Contractor's expense.

D. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earthwork only after test results for previously completed work comply with requirements.

E. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2922, and ASTM D 2937, as applicable. Tests will be performed at the following locations and frequencies:

1. Building slabs and footings: at subgrade and at each compacted fill and backfill layer, at least 1 test per 500 sq. ft. but in no case fewer than 1 test per lift regardless of area.
2. Paved Areas: at subgrade and at each compacted fill and backfill layer, at least 1 test per 2,000 sq. ft. but in no case fewer than 1 test per lift regardless of area.
3. Retaining wall footings: at each compacted initial and final backfill layer, at least 1 test for every 75 feet or less of footing length, but no fewer than 1 test per lift.
4. Utility trenches: at each compacted initial and final backfill layer, at least 1 test for every 150 feet or less of trench length, but no fewer than 1 test per lift.

F. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil to depth

required; recompact and retest until specified compaction is obtained. Costs related to re-testing due to unacceptable quality of work and failures discovered by the testing shall be borne by the Contractor.

G. Notify the Independent Testing Agency a minimum of 72 hours prior to start of earthwork operations, to comply with Code requirement that a registered design professional be present at all times during backfill to assure adequate compaction with no bridging effects. The services of the Testing Agency, Geotechnical Engineer, and the Designer shall include, but not be limited to, the following:

1. Observation during excavation, backfilling, and compaction.
2. Laboratory testing and analysis of fill materials specified or proposed for use as required.
3. Observation of construction and performance of water content, gradation, and compactions tests at a frequency and at locations that he/she shall selects. The results of these test will be submitted to the Owner's Representative so that the Contractor can take such action as is required to remedy any indicated deficiencies.
4. Observation of proof-compaction of exposed subgrades. Proof-compaction may be waived if, in the opinion of the Geotechnical Engineer, disturbance will occur and cause loss of strength of underlying soil.

H. The Contractor shall make provisions for allowing observations and testing of Contractor's Work by the Testing Agency and the Geotechnical Engineer, and the Designer. The presence of the Testing Agency, Geotechnical Engineering, and/or the Designer does not include supervision or direction of the actual work by the Contractor, his/her employees, or agents. Neither the presence of the Testing Agency, Geotechnical Engineer, and/or the Designer nor any observations and testing performed by those entities or any notice or failure to give notice, shall excuse the Contractor from defect discovered in his/her work.

3.23 PROTECTION

A. No excavation will be permitted below a line drawn downwards at 2 horizontal to 1 vertical from the underside of the closest edge of any proposed in-place footing or utility at a higher elevation without providing adequate sheeting and bracing or underpinning to prevent loss of support of the footing or utility.

B. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.

C. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.

1. Scarify or remove and replace soil material to depth as directed by Designer; reshape and recompact.

D. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.

1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.24 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Disposal: Contractor shall remove surplus satisfactory soil and waste material, including unsatisfactory soil, trash, and debris, and legally dispose of it off the Owner's property.

End of Section

SECTION 31 25 00
EROSION AND SEDIMENTATION CONTROLS

PART 1-GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.2 DESCRIPTION OF WORK

A. Work Included: Provide labor, materials, and equipment necessary to complete the work of this Section, including but not limited to the following:
   1. Control measures to prevent all erosion, siltation, and sedimentation of wetlands, waterways, construction areas, adjacent areas and off-site areas.
   2. Control measures shall be accomplished adjacent to or in the following work areas:
      a. Soil stockpiles and on-site storage and staging areas.
      b. Cut and fill slopes and other stripped and graded areas.
      c. Constructed and existing swales and ditches.
      d. Retention ponds.
      e. At edge of wetlands areas, if applicable, as shown on Drawings.
   3. The Contract Drawings indicate the minimum requirements for sedimentation and erosion control. The Contractor shall install all measures needed to control sediment and erosion as required by the Contractor and Sub-contractor's construction methods and operations, the weather conditions, and as directed by the Engineer.
   4. Additional means of protection shall be provided by the Contractor as required for continued or unforeseen erosion problems, at no additional cost to the Owner.
   5. Periodic maintenance of all sediment control structures shall be provided to ensure intended purpose is accomplished. Sediment control measures shall be in working condition at the end of each day.
   6. After any significant rainfall, sediment control structures shall be inspected for integrity. Any damaged device shall be corrected immediately.
   7. Maintain all erosion controls and systems established as part of Bid Package #1 Site Enabling, including maintaining stabilization of all slopes.

B. Alternates: Not Applicable.

C. Items to Be Installed Only: Not Applicable.

D. Items to Be Furnished Only: Not Applicable.

E. Related Work: The following items are not included in this Section and will be performed under the designated Sections:
   1. Section 311000 – SITE CLEARING for protection of existing trees and other vegetation to remain.
   2. Section 312000 – EARTH MOVING for soil materials, excavating, backfilling, and site grading and removal of site utilities.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

1. At least 20 days prior to the start of the project, the Contractor shall submit an Appendix by a qualified person to the Draft Stormwater Pollution Prevention Plan (SWPPP) indicating project phasing, Contractor operation areas, work areas, stockpile locations, construction staging/sequencing, and sedimentation and erosion control measures to be used. This Appendix shall become part of the SWPPP that is to be updated and maintained by the Contractor.
2. As part of the Contract Closeout procedures, the Contractor is responsible for filing a Notice of Termination with the EPA once the project has been completed and is permanently stabilized. Stabilization is complete when all temporary storm water and erosion controls have been removed, all permanent storm water and erosion controls are in place and functional and all vegetated areas are at least 70% viable.
3. The Contractor shall provide the manufacturer's literature, material specification, and installation instructions for sedimentation and erosion control materials and devices for approval. Do not order materials until approval of certifications or test results has been obtained. Delivered materials shall match the approved submittals.
4. LEED Supporting Documentation: Submit LEED supporting documentation as outlined in Section 018110 SUSTAINABLE DESIGN REQUIREMENTS for materials and products that have been extracted, harvested, or recovered, as well as manufactured within 500 miles of the project site.

1.4 QUALITY ASSURANCE

A. Comply with the requirements of Stormwater Pollution Prevention Plan prepared for the NPDES permit, which are incorporated herein by reference, and all other applicable requirements of governing authorities having jurisdiction. The specifications and drawings are not represented as being comprehensive, but rather convey the intent to provide complete slope protection and erosion control for both the project site and adjacent property.

1. Provide temporary erosion and sedimentation control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to a sediment and erosion control plan specific to the site, that complies with EPA 832/R-92-005 or requirements of The City of Worcester Conservation Commission, whichever is more stringent.

B. Erosion control measures shall be established at the beginning of construction and maintained during the entire period of construction. On-site areas which are subject to severe erosion, and off-site areas which are especially vulnerable to damage from erosion and/or sedimentation, are to be identified and receive special attention.

C. The Contractor shall install and maintain sedimentation control devices during construction to prevent the movement of sediment from the construction site to off-site areas, into adjacent water bodies via surface runoff or into underground drainage systems. Measures to prevent the movement of sediment off site shall be installed, maintained, removed, and cleaned up at no additional cost to the Owner.

D. All land-disturbing activities are to be planned and conducted to minimize the size of the area to be exposed at any one time, and the length of time of exposure.

E. Surface water runoff originating upgrade of exposed areas should be controlled to reduce erosion and sediment loss during the period of exposure.

F. When the increase in the peak rates and velocity of storm water runoff resulting from a land-disturbing activity is sufficient to cause accelerated erosion of the receiving stream bed, provide measures to control both the velocity and rate of release so as to minimize accelerated erosion and increased sedimentation of the stream.

G. All land-disturbing activities are to be planned and conducted so as to minimize off-site sedimentation damage.

H. The Contractor is responsible for cleaning out and disposing of all sediment once the storage capacity of the sediment facility is reduced by one-half.

I. Inspect, repair, and maintain erosion and sedimentation control measures during construction until permanent vegetation has been established.

J. Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.

1.5 REFERENCE STANDARDS

A. The following standards are applicable to the work of this Section to the extent referenced herein:

1. “Massachusetts Erosion and Sedimentation Control Guidelines for Urban and Suburban Areas, A Guide for Planners, Designers and Municipal Officials”, prepared by the Massachusetts Department of Environmental Protection, Bureau of Resource Protection, dated March 1997, reprinted May 2003.

1.6 EXAMINATION OF SITE AND DOCUMENTS

A. It is hereby understood that the Contractor has carefully examined the site and all conditions affecting work under this Section. No claim for additional costs will be allowed because of a lack of knowledge of existing conditions as indicated in the Contract Documents, or obvious from observation of the site.

B. Plans, surveys, measurements, and dimensions under which the work is to be performed are believed to be correct, but the Contractor shall have examined them for himself during the bidding period and formed his own conclusions as to the full requirements of the work involved.

1.7 PERMITS, CODES, AND REGULATIONS

A. Comply with the conditions of the Order of Conditions issued by the City of Worcester Conservation Commission for this project.

B. Comply with all rules, regulations, laws, and ordinances of the City and State, and all other authorities having jurisdiction over the project site. All labor, materials, equipment, and services necessary to make the work comply with such requirements shall be provided by the Contractor without additional cost to the Owner.

C. Comply with all applicable regulations of the Commonwealth of Massachusetts Department of Environmental Protection (DEP) and the EPA.

D. Comply with the requirements of the NPDES CGP for this project.

1.8 STORM WATER POLLUTION PREVENTION PLAN

A. A professional engineer has prepared a Draft Storm Water Pollution Prevention Plan (SWPPP). The Contractor shall locate the SWPPP and review its contents thoroughly. Upon the award of the Contract, the Contractor becomes responsible for implementing the SWPPP and meeting the requirements and standards detailed within the SWPPP. The Contractor is also responsible for all record keeping associated with maintaining the SWPPP and for maintaining in good operating condition all SWPPP controls. The Contractor shall modify the SWPPP as necessary to reflect changes in project scope, schedule, or approach. All labor, materials, equipment, and services necessary to make the work comply with such requirements shall be provided by the Contractor without additional cost to the Owner.

B. The Contractor shall fill out all pertinent information within the SWPPP.

C. The Contractor shall locate the EPA “Notice of Intent for Storm Water Discharges Associated with CONSTRUCTION ACTIVITY Under a NPDES General Permit” (NOI) form in the SWPPP. The Contractor is responsible for signing and filing his copy of the NOI at least 14 calendar days prior to the start of any construction activity and placing a signed copy along with proof of mailing in the SWPPP.

D. The Contractor is responsible for obtaining a copy of the Owner’s filed copy of the NOI form and proof of mailing and placing it in the SWPPP.

E. The Contractor is responsible for filling in the Contractor and Sub-Contractor information in the areas indicated within the SWPPP and for completing the Contractor’s Certification portion of the SWPPP.

F. The Contractor is responsible for maintaining the following records on site:
   1. Completed SWPPP as indicated in sections B, C, D, and E.
   2. Completed Inspection Reports
   3. Completed Maintenance Reports
   4. Construction Activity Reports
   5. Spill Records
   6. Other Materials relevant to the NOI Permit and SWPPP
   7. A copy of the Notice of Termination

G. The Contractor is responsible for filing a Notice of Termination once the project has been completed and is permanently stabilized. Stabilization is complete when all temporary storm water and erosion controls have been removed, all permanent storm water and erosion controls are in place and functional and all vegetated areas are at least 70% viable.

H. All labor, materials, equipment, and services necessary to make the work comply with the above requirements shall be provided by the Contractor without additional cost to the Owner.

PART 2-PRODUCTS

2.1 MATERIALS

A. Straw Bales: Wire or nylon bound bales of straw, oriented around sides, rather than over and under.

B. Stakes: Stakes for bales shall be one of the following materials: Wood stakes of sound hardwood 2 by 2 inches in size or steel reinforcing bars of at least No. 4 size. Lengths shall be approximately three feet.

C. Straw Wattles

1. Straw wattles shall consist of weed free rice straw inside biodegradable netting. Straw wattles shall measure at least 12 inches in diameter.
2. Stakes for wattles shall be one of the following materials. Lengths shall be approximately two feet (2').
   a. Wood stakes of sound hardwood, one inch by one inch (1" x 1") in size.
   b. Steel reinforcing bars of at least No. 4 size.

D. Siltation Fence

1. Fabricated or prefabricated unit consisting of the following filter fabric properties:
   a. Grab Tensile Strength (lbs) 124 ASTM D4632
   b. Elongation at Failure (%) 15 ASTM D4632
   c. Mullen Burst Strength (PSI) 280-300 ASTM D3786
   d. Puncture Strength (lbs) 60-65 ASTM D4833
   e. Water Flow Rate (gal/min/sf) 8-10 ASTM D4491
   f. Apparent Opening Size (Sieve) 30 ASTM D4751
   g. Ultraviolet Radiation Stability (%) 70-80 ASTM D4355
2. Use only commercially available fabric that is certified in writing by the manufacturer for the purpose intended.
3. Acceptable fabric materials include "Mirafi Envirofence" by Mirafi Construction Products, "Style 2130" by Amoco Fabrics Co., and "IVI 3617C Silt Fence" by Indian Valley Industries, Inc., or approved equal by the Engineer.
4. Silt fence posts: Posts may be wood or metal. Wood post shall be a minimum 1¼ inch by 1¼ inch by 5 feet long hardwood stakes commonly used to support siltation fabric. Metal posts shall be a minimum of 1 inch wide and 5 feet long. Posts shall be spaced at a maximum distance of 8 feet on center.
5. Provide suitable heavy nylon cord for securing abutting silt fence posts.

E. Fencing: Steel posts shall be standard 6-foot long metal stamped drive stakes commonly used to support snow fences. Fencing shall be new four-foot height wood lath snow fencing. Provide suitable steel staples or heavy nylon cord for securing filter cloth to support system.

F. Crushed Stone: Crushed Stone: Crushed stone shall consist of durable crushed rock or durable crushed gravel stone, free from ice and snow, sand, clay, loam, or other deleterious or organic material. The crushed stone shall be uniformly blended and shall conform to the following requirements.

Percent Passing by Weight		
Sieve Size	**1 1/2-inch Stone**	**3/4-inch Stone**
2-inch	100	---
1 1/2-inch	95-100	---
1 1/4-inch	---	---

Percent Passing by Weight		
Sieve Size	**1 1/2-inch Stone**	**3/4-inch Stone**
1-inch	35-70	100
3/4-inch	0-25	90-100
1/2-inch	---	10-50
3/8-inch	---	0-20
No. 4	---	0-5

G. Protective Measures: As temporary coverings on ground areas subject to erosion, provide one of the following protective measures, and as directed by the Designer with concurrence of the Owner's Representative:

1. Hay or straw temporary mulch, 100 pounds per 1,000 square feet.
2. Wood fiber cellulose temporary mulch, 35 pounds per 1,000 square feet.
3. Tackifier for anchoring mulch or straw shall be a non-petroleum based liquid bonding agent specifically made for anchoring hay or straw.
4. Provide natural (jute, wood excelsior) or man-made (glass fiber) covering with suitable staples or anchors to secure to ground surface. Note that wire staples and non-biodegradable coverings shall not be used for any area that will be mown turf.
5. Temporary vegetative cover for graded areas shall be undamaged, air dry threshed straw or hay free of undesirable weed seed.

H. Temporary Covers for Drainage Structures

1. Filter fabric for use as temporary covers for drainage structures shall be the same as noted above for siltation fence.
2. Wire mesh for use at temporary drainage structure covers shall be 6" x 6", W2.9 welded wire mesh.
3. Crushed stone shall be as specified herein before.
4. Silt-Sac, Hydro-FloGard + Plus Catch Basin Insert, Ultra-DrainGuard Insert, or approved equal, may be used in lieu of hay bales and filter fabric at catch basins.

PART 3-EXECUTION

3.1 GENERAL REQUIREMENTS

A. The Contractor shall provide suitable and adequate means of sedimentation and erosion control during construction. Control measures shall prevent all erosion, siltation, and sedimentation of waterways, drainage systems, construction areas, adjacent areas and off-site areas. Work shall be accomplished on and/or adjacent to the following work areas:

1. Earthwork stockpiles and on-site storage and staging areas.
2. Cut and fill slopes and other stripped and exposed graded areas.
3. Constructed and existing swales and ditches.
4. Unestablished lawns and seeded embankments.

B. Means of protection as noted on the Contract Drawings indicate the minimum provisions necessary. Additional means of protection shall be provided by the Contractor as required for continued or unforeseen erosion problems, at no additional expense to the Owner.

C. Periodic maintenance of all sediment control installations shall be provided to ensure intended purposes are accomplished. Sediment control measures shall be in working condition at the end of each day.

D. After any significant rainfall, sediment control devices shall be inspected for integrity. Any damaged device shall be corrected immediately.

E. The Contractor shall provide adequate means of control of runoff, as to not detrimentally impact downstream conditions during construction. The Contractor shall plan his operations so that permanent drainage mitigation systems such as detention/retention/infiltration basins and chambers are in place and properly functioning prior to connecting upland drainage flows to these systems. The Contractor shall plan his operations such that downstream drainage mitigation measures are in place and functioning before attempting to tie in upgradient drainage systems.

F. In the event that the Contractor is unable to sequence the work so that construction of the permanent drainage mitigation systems precedes the upland work, then the Contractor shall submit a plan indicating his proposed methods of otherwise controlling runoff from the site.

G. The "Massachusetts Erosion and Sedimentation Control Guidelines for Urban and Suburban Areas" should be consulted as a guide for the selection and installation of Best Management Practices to suit the conditions encountered.

3.2 STRAW BALE BARRIERS

A. Excavation shall be to the width of the bale and the length of the proposed barrier to a minimum depth of 4 inches.

B. Bales shall be placed in a single row, lengthwise on proposed line, with ends of adjacent bales tightly abutting one another. In swales and ditches, the barrier shall extend to such a length that the bottoms of the end bales are higher in elevation than the top of the lowest middle bale.

C. Staking shall be accomplished to securely anchor bales by driving at least two stakes or rebars through each bale to a minimum depth of 18 inches.

D. The gaps between bales shall be filled by wedging straw in the gaps to prevent water from escaping between the bales.

E. The excavated soil shall be backfilled against the barrier. Backfill shall conform to ground level on the downhill side and shall be built up to 4 inches on the uphill side. Loose straw shall then be scattered over the area immediately uphill from a straw barrier.

F. Inspection shall be frequent and repair or replacement shall be made promptly as needed.

G. Bales shall be removed when they have served their usefulness so as not to block or impede stormwater flows or drainage.

3.3 STRAW WATTLE BARRIERS

A. Install straw wattles in locations as shown on Contract Drawings and as directed.

1. Wattles shall be placed in a row with ends overlapping a minimum of two (2) feet.
2. Each wattle shall be embedded in the soil a minimum of two (2) and a maximum of six (6) inches.

3. Wattles shall be securely anchored in place by stakes or rebars driven through the wattles and a minimum twelve (12) inches into the soil. Stakes shall be placed four (4) feet on center.

B. Inspection shall be frequent and repair or replacement shall be made as needed.

C. Wattles shall be removed when they have served their usefulness so as not to block or impede stormwater flows or drainage.

3.4 STABILIZED CONSTRUCTION ENTRANCE AND STONE BERMS

A. Stone size: Use ASTM designation C-33, size No. 2 (1-1/2" to 2-1/2"). Use crushed stone.

B. Length: As effective, but not less than 50 feet.

C. Thickness: Not less than eight inches.

D. Width: Not less than full width of all points of ingress or egress, but not less than 25 feet.

E. Washing: When necessary, wheels shall be cleaned to remove sediment prior to entrance onto public right-of-way. When washing is required, it shall be done on an area stabilized with crushed stone which drains into an approved sediment trap or sediment basin. All sediment shall be prevented from entering any storm drain, ditch, or watercourse through the use of sand bags, gravel boards or other approved methods.

F. Maintenance: The entrance shall be maintained in a condition which will prevent tracking or flowing of sediment onto public rights-of-way. This may require periodic top dressing with additional stone as conditions demand and repair and/or cleanout of any measures used to trap sediment. All sediment spoiled, dropped, washed or tracked onto public rights-of-way must be removed immediately.

G. Place crushed stone berms in locations required and as directed. Berms shall have side slopes of 1:3 or less.

H. Inspect stone berms periodically and replace and/or regrade crushed stone as required.

3.5 SILT FENCING

A. Excavate a 6-inch trench along the upstream side of the desired fence location.

B. Drive fence posts a minimum of 1'-6" into the ground. Install fence, well-staked at maximum eight-foot intervals in locations as shown on Drawings. Secure fabric to fence and bury fabric end within the six-inch deep trench cut.

C. Lay lower 12 inches of silt fence into the trench, 6 inches deep and 6 inches wide. Backfill trench and compact.

D. Overlap joints in fabric at post to prevent leakage of silt at seam.

E. Inspect siltation fence after major storm events and periodically and remove accumulated sediment and debris. If a breach or failure of the siltation fence occurs, the fence shall immediately be restored.

3.6 EROSION CONTROL GRASSING

A. Grassing shall be applied according to the Massachusetts Erosion and Sedimentation Control Guidelines for Urban and Suburban Areas, A Guide for Planners, Designers and Municipal Officials.

3.7 INLET PROTECTION

A. Install silt fence or straw bales around inlet as specified herein.

B. Install temporary covers at drainage structure locations that may be subject to erosion infiltration and as directed by the Engineer.

C. Inspect drainage structures periodically. Remove sediment accumulation and regrade or replace materials as required.

3.8 DUST CONTROL

A. Throughout the construction period the Contractor shall carry on an active program for the control of fugitive dust within all site construction zones, or areas disturbed as a result of construction. Control methods shall include the following: Apply calcium chloride at a uniform rate of one and one-half (1 ½) pounds per square yard in areas subject to blowing. For emergency control of dust apply water to affected areas. The source of supply and the method of application for water are the responsibility of the contractor.

B. The frequency and methods of application for fugitive dust control shall be as directed by the Designer with concurrence by the Owner's Representative.

3.9 TEMPORARY PROTECTIVE COVERINGS

A. Place temporary soil coverings to control erosion and sedimentation on all disturbed or graded areas as required by the construction methods employed and as directed by the Engineer. Erosion control matting shall be installed in all areas seeded or hydroseeded with slopes of one vertical foot to three-foot horizontal, or steeper, immediately after such areas have been seeded and a hay mulch applied as follows:

1. The area to receive matting shall have been recently seeded and shall have a smooth surface free front stones, clods or depressions.
2. Roll out of the matting perpendicular to the slope, do not stretch the fabric. In drainage swales, center the fabric along the flow line. Install the matting in a check slot at the top and bottom of the slope and at the edges of the area to be covered. Check slots shall be six inches deep and six inches wide. Fabric shall extend down one wall of the check slot and across the full width of the base. Overlap edges of matting rolls four (4) inches minimum and overlap the ends eighteen (18) inches minimum.
3. Install staples in check slots, edges, center, and ends of rolls by driving specified steel staples two feet on center over the entire area to be covered except at check slots and ends of rolls, where staples shall be placed six inches on center. All staples shall be driven below finished grade.
4. Fill check slots with loam and tamp firmly.
5. Reseed check slots and all disturbed areas per Specifications.
6. Following matting installation, roll the entire area with a smooth drum roller weighing between fifty and seventy-five (50-75) pounds per linear foot of roller. The finished installation of matting shall be firmly in contact with the seeded area and provide a smooth, finished appearance free from lumps or depressions.

B. Install erosion control matting as a temporary ground cover in all disturbed or graded areas subject to erosion and as directed by the Engineer. The temporary ground cover shall protect the site from erosion until a full permanent lawn can be installed. Install and anchor in place temporary erosion control matting in accordance with manufacturer's printed instructions or as directed by the Engineer and remove all temporary erosion control matting prior to installation of a permanent lawn.

C. Inspect protective coverings periodically and reset or replace materials as required.

3.10 TEMPORARY PROTECTIVE COVERINGS (AFTER GROWING SEASON)

A. Place temporary covering for erosion and sedimentation control on all areas that have been graded and left exposed after October 30. Contractor shall have the choice to use either or both of the methods described herein.

B. Hay or straw shall be anchored in-place by one of the following methods and as approved by the Designer with concurrence by the Owner’s Representative: Mechanical “crimping” with a tractor drawn device specifically devised to cut mulch into top two inches of soil surface or application of non-petroleum based liquid tackifier, applied at a rate and in accordance with manufacturer’s instructions for specific mulch material utilized.

C. Placement of mesh or blanket matting and anchoring in place shall be in accordance with manufacturer’s printed instructions.

D. Inspect protective coverings periodically and reset or replace materials as required.

3.11 REMOVAL AND FINAL CLEANUP

A. Once the site has been fully stabilized against erosion, and with the approval of the Owner’s Representative remove sediment control devices and all accumulated silt. Dispose of silt and waste materials offsite. Regrade all areas disturbed during this process and stabilize against erosion with surfacing materials as indicated.

End of Section

SECTION 32 12 16
ASPHALT PAVING

PART 1-GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.2 DESCRIPTION OF WORK

A. Work Included: Provide labor, materials and equipment necessary to complete the work of this Section, including but not limited to the following:

1. Hot-mix asphalt (HMA) paving, including walkways, ramps, and curbs.
    a. Hot-mix asphalt shall be composed of mineral aggregate and asphalt binder, mixed in a central mixing plant and placed on a prepared course in accordance with these specifications and conformance to the lines, grades, thickness and typical cross sections shown on the plans or as directed by the Designer.
    b. Each course shall be constructed to the depth, typical section, or elevation required by the contract and/or plans and shall be rolled, finished, and approved before the placement of the next course. Each course shall be placed to a smooth, dense, and uniform appearance.
2. Sawcutting existing pavements.
3. Asphalt Emulsion for Tack Coat.
4. Hot Poured Joint Sealer.
5. Hot-mix asphalt patching.
6. Hot-mix asphalt overlays, including surface preparation, leveling courses, tack coating and all other associated operations required.

B. Alternates: Not Applicable.

C. Items To Be Installed Only: Not Applicable.

D. Items To Be Furnished Only: Not Applicable.

E. Acceptance: The acceptance of plant produced material for gradation, asphalt content, and air voids shall be determined by the Designer in accordance with the requirements of the section on acceptance criteria, herein specified.

F. Related Work: The following items are not included in this Section and will be performed under the designated Sections:

1. Section 312300 – EXCAVATION & FILL FOR UTILITIES AND PAVEMENT for aggregate subbase and base courses and for aggregate pavement shoulders.
2. Section 321313 – CONCRETE PAVING for installation of cement concrete paving for driveways, walkways, and sidewalks.

3. Section 321613 – CURBS AND GUTTERS for installation of granite curb, granite edging, curb inlets, and curb corners, precast concrete curb and cast-in-place concrete curb.
4. Section 321723 – PAVEMENT MARKINGS for placement of pavement markings.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

B. Product Data: For each type of product indicated. Include technical data and tested physical and performance properties.
1. Proof of a State or local municipality Department of Transportation's pre-approved Job Mix Formula (JMF).
2. Tack Coat.
3. Hot Applied Joint Sealer.
4. Seal Coat.
5. JMF's for driveways, sidewalks, berm, and curb.

C. Material Certificates: For each paving material, from manufacturer.
1. Submit certified test reports signed by the material producer and Contractor certifying that materials comply with, or exceed, the specification requirements. The Owner reserves the right to employ an independent testing laboratory for testing materials included in the JMF, and the Contractor shall, upon request by the Owner, supply suitable quantities of these materials for testing.

1.4 REFERENCE STANDARDS

A. The following standards are applicable to the work of this Section to the extent referenced herein:
1. Commonwealth of Massachusetts, Massachusetts Department of Transportation (MassDOT), Highway Division, Standard Specifications for Highways and Bridges, latest English Edition with amendments. All references to method of measurement, basis of payment and payment items in the Standard Specifications are hereby deleted. References made to particular sections or paragraphs in the Standard Specifications shall include all related articles mentioned herein.
2. ASTM: American Society for Testing and Materials
3. AASHTO: American Association of State Highway and Transportation Officials
4. ACI: American Concrete Institute
5. MUTCD: Manual on Uniform Traffic Control Devices

B. Pavement within public rights-of-way. The construction of all pavements within public rights-of-way shall be in accordance with the rules, regulations and requirements of the City of Worcester Department of Public Works.

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: A paving-mix manufacturer registered with and approved by MassDOT, Highway Division.

B. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of MassDOT, Highway Division for hot mix asphalt paving work.

1. Comply with requirements of MassDOT, Highway Division, Standard Specifications for Highways and Bridges, including supplemental specifications and special provisions.
2. Comply with requirements of the Americans with Disabilities Act (ADA) and the Massachusetts Architectural Access Board (MAAB). If these requirements cannot be met with the grades and slopes indicated on the plans, notify the Designer immediately.
3. Comply with requirements of the local authority having jurisdiction concerning the location and construction of accessible curb cuts.

C. The Contractor shall establish, provide, and maintain a Quality Control System (QCS) that will detail the methods and procedures that will be taken to assure that all materials and completed construction conform to project specifications, plans, technical specifications and other requirements, whether manufactured or processed by the Contractor or procured from subcontractors or vendors. The Contractor will be required to complete daily Quality Control testing for the RAP material for each day of production in accordance with these specifications.

1. The Contractor assumes the responsibility of the quality for all materials and construction incorporated into the work and will control all the processes leading to the final result through this function. Quality Control activities should include:
   a. Maintain a Contractor Quality Control System.
   b. Proficiency Testing prior to production with the Independent Testing Agency.
   c. Inspection and Testing of Hot Mix Asphalt Production.
   d. Inspection and Testing of Hot Mix Asphalt Placement.
2. See Section 3.3 “Contractor Quality Control of HMA Pavement” of these specifications for additional information.

D. The Owner, or their authorized representatives, will perform the Quality Acceptance function for this work. All material will be considered for acceptance through a sampling, testing and inspection program performed by the Independent Testing Agency. Quality Acceptance activities include:

1. Proficiency Testing prior to production with Contractor.
2. Inspection of HMA Production Plant and Testing Laboratory.
3. Production Trials of HMA Products Intended for the Project.
4. Inspection/Testing for Acceptance of Hot Mix Asphalt Production.
5. Inspection/Testing for Acceptance of Hot Mix Asphalt Placement.
6. HMA Quality Acceptance Daily Report of Activities.

E. Preinstallation Conference:

1. Prior to the placing of any HMA, a pre-paving conference shall be held to discuss and approve the paving schedule, source of HMA, Job Mix Formula/Design Mix Formula approvals, type and amount of equipment to be used, sequence of paving pattern, rate of HMA supply, all sampling, testing and reporting procedures to be used, traffic control, safety, and general continuity of the operation. Designers, Contractor’s plant, quality control and field representatives and Owner’s Independent Testing Agency’s testing and inspection agents shall attend this meeting. All equipment used shall be approved on the project site prior to starting up each day.

2. Conduct conference at Project site to comply with requirements in Division 01.
3. Review methods and procedures related to hot-mix asphalt paving including, but not limited to, the following:
   a. Review proposed sources of paving materials, including capabilities and location of plant that will manufacture hot-mix asphalt.
   b. Review condition of subgrade and preparatory work.
   c. Review requirements for protecting paving work, including restriction of traffic during installation period and for remainder of construction period.
   d. Review and finalize construction schedule and verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
4. Coordination. The Contractor shall coordinate and schedule the Work under this specification with all other work, including underground utility improvement construction, to avoid covering up incomplete, unfinished, and/or uninspected work. Any repaving required due to uncoordinated and/or improper scheduling shall be done by the Contractor at no cost to Owner.

1.6 PROJECT CONDITIONS

A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

B. Weather Limitations.

1. HMA shall only be placed on dry, unfrozen surfaces. The underlaying surface shall be approved by the Owner's Representative and/or Designer prior to placement of any HMA. Underlaying surfaces shall be cleaned of any foreign materials.
2. The HMA shall not be placed when weather conditions of fog or rain prevail or when the pavement surface or base shows signs of free moisture (film of water) or when the air and/or surface temperature is less than the temperature requirements contained in MassDOT Specifications Table 450.42-1. When the surface temperature of the underlying course is less than 50°F the Contractor shall determine the time available for compaction. The Contractor shall also take extra precautions to control the temperature of the materials during placement. The time available for compaction shall be calculated based on the time, date, air temperature, average wind speed, sky conditions, latitude, mix type, PG grade, lift thickness, mix delivery temperature, existing surface type, existing moisture content of surface, existing state of moisture in surface, and surface temperature. The estimated time available for compaction can be calculated with computer programs, e.g., Pave Cool Tool. This program is available at the following web location: http://www.dot.state.mn.us/app/pavecool/
3. The information regarding the air temperature, average wind speed, sky conditions, mix delivery temperature, and existing moisture conditions shall be evaluated by the Designer and a Contractor's representative located at the paving operation. The estimated time available for compaction shall be provided by the Contractor to the Designer. The Designer and the Contractor shall determine if there is an adequate amount of time available to compact the mixture. Options can be explored to extend the time available for compaction. If there is an adequate amount of time available to compact the mixture, the temperature requirements may be waived by the Designer; however, all other requirements including compaction shall be met. The Contractor assumes responsibility for constructing the pavement to meet compaction and specification requirements.

4. The Contractor shall not permit work to continue when overtaken by sudden storms until the pavement surface shows no signs of free moisture. The material in transit at the time of shutdown will not be placed until the pavement surface shows no signs of free moisture, provided the mixture is within temperature limits as specified.
5. When the air temperature falls below 50°F, extra precautions shall be taken in drying the aggregate, controlling the temperature of the materials, and in placing and compacting the mixtures.
6. The construction of hot mix asphalt concrete pavements shall terminate on November 15 and shall not be resumed prior to April 1 except as determined and directed in writing by the Designer.

1.7 EXAMINATION OF SITE AND DOCUMENTS

A. It is hereby understood that the Contractor has carefully examined the site and all conditions affecting work under this Section. No claim for additional costs will be allowed because of a lack of knowledge of existing conditions as indicated in the Construction Documents, or obvious from observation of the site.

B. Plans, surveys, measurements, and dimensions under which the work is to be performed are believed to be correct, but the Contractor shall have examined them for himself during the bidding period and formed his own conclusions as to the full requirements of the work involved.

1.8 ADA AND MAAB COMPLIANCE

A. Comply with American with Disabilities Act (ADA) and the requirements of the Massachusetts Architectural Access Board (MAAB).
1. Slopes: Walkways as defined by Section 22.1 of 521 CMR, shall be graded to a maximum of 4.5%. The cross-pitch (perpendicular to travel) for walkways and paths shall be constructed at 1.5%. The slopes of ramps and side slopes on handicap curb cuts as defined by Section 21.1 of 521 CMR shall be constructed at 7.5% maximum. Ramps as defined in Section 24.1 of 521 CMR, shall be constructed to a maximum slope of 7.5%.
2. The Contractor is to assume that sidewalk grades will be verified and checked with a 2-foot long electronic ‘smart level’.
3. A 5’-0” minimum level, 1.5% pitch, area shall be provided at entrances to buildings. Puddling or ponding of water at the entrances will not be accepted.
4. Handicap parking spaces and access aisles shall be graded level with the slope not to exceed 1.8% in any direction.
5. The requirements specified hereinabove shall supersede the grades indicated on the Drawings. If these requirements cannot be met with the grades indicated on the Drawings, the Designer shall be notified immediately for direction.

PART 2-PRODUCTS

2.1 HOT MIX ASPHALT

A. General
1. Hot Mix Asphalt (HMA) shall conform to MassDOT Standard Sections 450.10, 450.30, and M 3.11.00, and as required herein. All HMA mixtures shall meet the requirements of the Superpave volumetric mix design system.

2. HMA designs shall meet the requirements of MassDOT Standard Specification Section 450.30
    a. Each HMA pavement course placed shall be comprised of one of the mixtures listed in MassDOT Standard Specifications Table 450.10-1: HMA Pavement Courses & Mixture Types
3. Asphalt mixtures shall be composed of the following:
    a. Mineral aggregate
    b. Mineral filler (if required)
    c. Performance Graded Asphalt Binder (PGAB)
        1) All mixes shall be PG 64-28
4. The use of recycled materials shall be at the Contractor's option in accordance with MassDOT Standard Section M3.11.00. As permitted, recycled materials shall be limited to Recycled Asphalt Pavement (RAP). Maximum amount of RAP allowed shall be per MassDOT Standard Table M3.11.2-1.
5. Warm Mix Asphalt. Warm Mix Asphalt shall be HMA modified using a Warm Mix Asphalt Additive. WMA shall be per MassDOT Standard Specifications Section M3.01.4.
    a. Shall meet the requirements of AASHTO R 25 Appendix X2: Special Mixture Design Considerations and Practices for Warm Mix Asphalt (WMA).
    b. Laboratory mixing and compaction temperatures shall be reduced per the WMA Manufacturer's recommendations.
    c. WMA additive equipment shall be fully automated and integrated into the HMA plant controls. No WMA foaming technology which requires the mechanical injection of steam or water into the liquid asphalt will be permitted.

B. RECLAIMED PAVEMENT BORROW MATERIAL

1. All reclaimed material shall conform to the requirements of MassDOT Standard Specification Section M1.09.1, Reclaimed Pavement Borrow Material.
2. Reclaimed Pavement Borrow material shall consist of crushed asphalt pavement and/or crushed cement concrete, and gravel borrow meeting MassDOT Standard Specification Section M1.03.0, Gravel Borrow. The material shall be free of loam, clay, and deleterious materials such as brick, reinforcing steel, wood, paper, plaster, lathing, and building rubble, etc.
3. Before reuse of onsite reclaimed pavement borrow, the materials shall be tested by the Owner's Independent Testing Agency for hazardous contaminates including asbestos.
4. The coarse aggregate shall have a percentage of wear not greater than 50 as measured by the Los Angeles Abrasion Test.
5. Gradation requirements shall be determined by AASHTO T 11 and T 27 except the material shall not be oven dried. It shall be air dried, fan dried at low speed, or other low temperature heat so as not to liquefy the asphalt or cause the asphalt to adhere to the sieves. Water used for the No. 200 sieve analysis shall be cold tap water.
6. The gradation shall meet the following requirements:

Gradation Requirements for Reclaimed Pavement Borrow

Sieve Designation	Percent Passing
3 in.	100
1 ½ in.	70-100
¾ in.	50-85
No. 4	30-60
No. 50	8-24
No. 200	0-10

7. The portion of material passing the No. 40 sieve shall have a liquid limit not greater than 25 and a plasticity index not greater than 6. The reclaimed pavement borrow shall be compacted to a minimum of 95% of AASHTO T 180 proctor density. Liquid limits shall be determined by AASHTO T 90.
8. Reclaimed pavement borrow material shall be processed by mechanical means and blended to form a homogeneous material. The equipment for producing crushed material shall be of adequate size and have sufficient adjustments to produce the desired materials. Blended materials that are stockpiled for more than 3 months shall be reworked to a uniform material and retested prior to use however, the Owner's Representative and/or Designer may require additional testing any time the materials appear excessively hard, wet and/or segregated. The processed materials shall be stockpiled in such a manner as to minimize segregation of particle sizes. All reclaimed pavement borrow material shall come from approved sources and stockpiles.
9. The amount of combined crushed asphalt pavement and crushed cement concrete shall not exceed 50% by volume as determined by visual inspection and/or laboratory tests.

2.2 AUXILIARY MATERIALS

A. Herbicide: Commercial chemical for weed control, registered by the EPA. Provide in granular, liquid, or wettable powder form.

2.3 HOT MIX ASPHALT BERM AND CURB – NOT USED

2.4 SEALCOAT – NOT USED

2.5 ASPHALT EMULSION FOR TACK COAT

A. Asphalt emulsion materials shall be homogeneious and shall show no separation after mixing within 30 days after deliveries. They shall conform to the requirements of AASHTO M 140. Anionic emulsion used for tack coat shall be grade RS-1h.

2.6 HOT POURED JOINT SEALER – NOT USED

PART 3-EXECUTION

3.1 GENERAL

A. Subbase under paving shall be compacted as described in Section 312000, EARTH MOVING. Add material meeting the requirements of ordinary borrow to bring the subgrade to the required grade as necessary before placing base course.

B. The Contractor shall furnish, set, and maintain all line and grade stakes necessary to guide the automated grade control equipment. Where required these control stakes shall be maintained by the Contractor and used throughout the operations, from the grading of the subbase material up to and including the final layers of the pavement.

C. The gravel base course shall be spread in layers upon the prepared subgrade conforming to the required line and grade. Gravel shall be placed in compacted layers not more than 4 inches thick compacted to not less than 95 percent of the maximum dry density of the material. Any stone greater than 3 inches in size shall be removed. Compaction shall continue until the surface is even and true to line and grade.

D. Gravel base course shall be placed on backfilled and compacted trenches to proper grade before placement of pavement.

E. The edges of existing pavement that is to remain shall be sawcut to an even, straight edge using a power-driver rotary saw; use of a jackhammer is unacceptable. This includes road, parking lot, sidewalk, and utility trench edges.

1. The pavement shall be sawcut through its full depth at all joints between existing and proposed pavements, and at all utility trenches, to provide a uniform, smooth vertical surface.
2. Sawcut edges which become broken, ragged or undermined as a result of the Contractor's operations shall be re-cut prior to the placement of abutting proposed pavement at no additional cost to the Owner.
3. Sawcut surfaces in asphalt pavements shall be sprayed or painted with a uniform, thin coat of asphalt emulsion tack coat immediately before placement of hot mix asphalt against the cut surface.

F. Asphalt courses shall be spread and compacted to the finished thicknesses as shown on the Contract Drawings. A smooth even surface shall be produced.

G. Any joints at junctions of old and new pavements shall be sealed with hot poured joint sealer and covered with sand.

H. All structures must be set flush with base course at areas where the final top course is scheduled for a future phase, and re set/readjusted prior to paving the final course, refer to the Construction Manager's phasing requirements.

3.2 EXAMINATION

A. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.

B. Proof-roll subgrade below pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

C. Proceed with paving only after unsatisfactory conditions have been corrected.

3.3 CONTRACTOR QUALITY CONTROL OF HMA PAVEMENT

A. General. Contractor Quality Control (QC) shall be in conformance with MassDOT Standard Specifications Section 450.60 through 450.68 and required as indicated. The Contractor assumes the responsibility of the quality for all materials and construction incorporated into the work and will control all the processes leading to the final result through this function.

The QC system addresses all elements which affect the quality of the pavement including, but not limited to:

1. Mix Design
2. Aggregate Grading
3. Quality of Materials
4. Stockpile Management
5. Proportioning
6. Mixing and Transportation
7. Placing and Finishing
8. Joints
9. Compaction
10. Surface smoothness and uniformity
11. Thickness and grade

B. Independent Testing Agency. The Contractor shall cooperate with the Independent Testing Agency engaged by Owner for field quality control activities for the Work of this Section. Refer also to Section 014325 - TESTING AGENCY SERVICES.

C. The Contractor shall be prepared to discuss and present, at the pre-paving conference, their understanding of quality control for this contract.

D. Field Quality Control.

1. HMA material placed in the field shall be tested for both joint and mat density on a completed street or public facility basis. The Independent Testing Agency may conduct any necessary testing to monitor that the specified density, uniformity and smoothness is being achieved. A properly correlated nuclear gauge may be used to monitor the pavement density in accordance with ASTM D2950.
    a. Sampling.
        1) Samples shall be neatly cut with a core drill. The cutting edge of the core drill bit shall be of hardened steel or other suitable material with diamond chips embedded in the metal cutting edge. The minimum diameter of the sample shall be 4 inches. The minimum diameter of the base samples shall be 6 inches. Samples that are clearly defective, as a result of sampling, shall be discarded and another sample taken. Cores shall be taken within 48-hours of placement of the HMA.
        2) The Contractor shall furnish all tools, labor, and materials for cutting samples and filling the cored pavement. Pavement cores will be taken upon project pavement completion to determine the average percent density. Cores will be taken randomly by the Independent Testing Agency based on five cores for mat density and three cores for longitudinal joint density per 1000 tons of material placed. A minimum of five core samples for mat and three core samples for joint density will be removed from each course and construction phase or 40,000 square feet of paving. The average density of the core samples will be used to determine the density of the pavement course. The removal and patching of cores shall be paid for by the Owner. Cored holes shall be filled by the Contractor in a manner acceptable to the Owner's Representative and/or Designer and within one day after sampling. Resampling of pavement shall be in accordance with applicable provisions

of the Northeast Transportation Training and Certificate Program (NETTCP) Quality Assurance Technologist Manual, latest edition.

b. Testing.

1) The bulk specific gravity of each cored sample will be measured by the Independent Testing Agency in accordance with AASHTO T 166 or AASHTO T 275, whichever is applicable. The theoretical maximum specific gravity shall be the average maximum specific gravity for the project pavement in accordance with the plant-produced material section. The theoretical value used for the percent density of the core samples shall be the average of the measurements for maximum specific gravity for the project pavement course. The percent density of each sample will be determined in accordance with AASHTO T 269, using the bulk specific gravity of each sample and the average theoretical maximum specific gravity. Retesting of pavement shall be in accordance with applicable provisions of the NETTCP Quality Assurance Technologist Manual, latest edition.

a) Mat Density. Core locations will be determined by the Independent Testing Agency on a random basis in accordance with procedures contained in ASTM D3665. Cores shall not be taken closer than 1 foot from a longitudinal joint and 10 feet from a transverse joint.

b) In place density shall be measured during paving operations by a density gauge. Testing shall be performed randomly throughout the paving operation.

c) Joint Density. Three 6-inch diameter cores of finished longitudinal joint, will be taken by the Independent Testing Agency from each course and construction phase. Core locations will be determined by the Independent Testing Agency on a random basis over the joint, not adjacent to the joint.

2. Surface Smoothness.

a. The finished surfaces of the pavement shall be uniform in appearance, free from irregularities in contour and texture and shall present a smooth-riding surface. Smoothness evaluation applies to all hot mix asphalt concrete roadways and walkways receiving 1.5 inches or more in plan (compacted) thickness of HMA pavement.

b. The Contractor shall carefully apply the straight edge immediately after the first compaction by rolling, and from then on as may be necessary until and after the final compaction of the material in place. Hold the straightedge in successive positions parallel to the road centerline and in contact with the road surface; check the entire area from one side of the pavement to the other.

1) Tests for conformity with the specified crown and grade shall be made by the Contractor immediately after initial compaction. Any variation shall be corrected by the removal or addition of materials and by continuous rolling.

2) The finished surface of the pavement, when measured with a 10-foot straightedge, shall not vary more than ¼ inch for the surface course and ⅜ inch for the intermediate course measured perpendicular and parallel to the centerline.

3) After the completion of final rolling, the smoothness of the course shall again be tested.

c. Humps or depressions exceeding the specified tolerances shall be immediately corrected by removing the defective work and replacing with new material, as

directed by the Owner's Representative and/or Designer. This shall be done at the Contractor's expense.

d. Skin patching will not be permitted.

e. When profile corrections are required, the Contractor shall use one or more of the following corrective methods:
   1) Removing and replacing the entire pavement thickness.
   2) Diamond grinding or micro milling.
   3) Overlaying (not patching) with the specified surface course.
   4) Removing the surface by milling and applying a lift(s) of the specified course(s).
   5) Use of other methods that will provide the desired results.

f. The corrective method(s) chosen by the Contractor shall be performed at the Contractor's expense, including all necessary equipment and traffic control.
   1) Areas of removal and replacement shall be removed the full width of the lane or paver pass. The removal areas shall begin and end with a transverse butt joint which shall be constructed with a transverse sawcut perpendicular to the centerline or paver pass.
   2) Replacement materials shall be placed in sufficient quantity, so the finished surface will conform to grade and smoothness requirements. The corrective area shall conform to all material and density specification requirements.
   3) When the corrective work consists of an overlay, the overlay shall cover the full width of the pavement including shoulders or the paver passes sufficient to correct the defective work. The area overlaid shall begin and end with a transverse butt joint which shall be constructed with a transverse sawcut and asphalt removal.
   4) All materials shall meet contract requirements. The overlay shall be placed so the finished surface will conform to grade and smoothness requirements. The overlaid area shall be compacted to the specified density.

g. The Owner's Representative and/or Designer can have the Independent Testing Agency retest any sections where corrections were made to verify that the corrections produced a surface that conforms to the grade and smoothness requirements.

3. Uniformity.
   a. The HMA mat shall be smooth, dense, and uniform. Uniformity is generally affected by Thermal and/or Aggregate segregation.
   b. If segregation is evident and discernable by either the Contractor or the Owner's Representative/Designer, the Contractor shall immediately cease production and take steps to correct and eliminate the cause(s) of the segregation.
   c. The Contractor shall review all potential causes of segregation as it relates to its operation, including but not limited to HMA Plant issues, loading and transportation issues, placement issues, thermal segregation, and hand work. The Contractor shall employ additional investigation methods and make the necessary changes in their operation such that segregation is eliminated, and mat uniformity is acceptable.

4. Thickness.
   a. The thickness requirements contained herein shall apply only when each pavement layer is specified to be a uniform compacted thickness of 1 inch or

greater. Thickness shall be evaluated for acceptance by the Owner's Representative and/or Designer to the requirements shown on the plans. Measurements of thickness may be checked periodically by the Contractor in following their QC system for field operations. Measurements of thickness for acceptance shall be made by the Independent Testing Agency using 4-inch minimum diameter pavement cores removed also for subsequent density measurement.

b. The finished surfaces of each HMA pavement course shall not vary from that specified or cross sections shown on the contract drawings by more than ¼ inch. The Contractor shall correct pavement areas varying more than this amount by removing and replacing the defective work or as ordered by the Owner's Representative and/or Designer. Skin patching will not be permitted.

5. Grade.

a. The finished surface of the pavement shall not vary from the gradeline elevations as shown on the plans by more than ½ inch. The Contractor shall remove deficient areas and replace with new material. Sufficient material shall be removed to allow at least 1 ½ inches of hot mix asphalt to be placed. Skin patching for correcting low areas shall not be permitted. High points may be ground off.

6. Rejection of Inferior HMA.

a. The Owner's Representative and/or Designer may at any time, notwithstanding previous acceptance, reject and require the Contractor to dispose of any batch of hot mix asphalt which is rendered unfit for use due to contamination, segregation, incomplete coating of aggregate, or improper mix temperature. Such rejection may be based on only visual inspection or temperature measurements. Similarly, the Owner's Representative and/or Designer may at any time, notwithstanding field acceptance for mat density, reject and require the Contractor to correct any HMA pavement that was placed with unacceptable mat uniformity or paving joints due to low density, segregation, improper elevation, or tearing. In the event of such rejection, the Contractor and the Owner's Representative and/or Designer may take random split samples of the area(s) in question, and if it can demonstrate in the laboratory, in the presence of the Owner's Representative and/or Designer, that such material/pavement was erroneously rejected, payment will be made for the material at the contract unit price.

3.4 RECLAIMED PAVEMENT – NOT USED

3.5 PAVEMENT MILLING

A. This work shall consist of milling and removal of existing asphalt pavement from the project by the Contractor in areas designed on the Contract Drawings. Milling shall be performed in conformity with the limits, line, grade, and typical cross-section shown on the plans. The milling operation shall be categorized as either Standard Milling, Fine Milling, or Micro Milling, as defined MassDOT Standard Specification Table 415.2.1. The milled material shall become the property of the Contractor to be properly removed and disposed.

B. Milling Equipment Requirements. The milling equipment shall be self-propelled with sufficient power, traction, and stability to remove the existing asphalt pavement to the specified depth and cross-slope. The milling machine shall be capable of operating as a minimum speed of 10 feet per minute, designed so that the operator can always observe the

milling operation without leaving the control area of the machine, and be equipped with the following:

1. A built-in automatic grade control system that can control the longitudinal profile and the transverse cross-slope to produce the specified results.
2. Longitudinal controls capable of operating from any longitudinal grade reference, including string line, 30-ft ski minimum, 30-ft mobile string line minimum, or a matching shoe.
3. The transverse controls shall have an automatic system for controlling cross-slope at a given rate.
4. Cutting heads able to provide a minimum 6 ft cutting width and a 0 to 4 in. deep cut in one pass. The teeth on the revolving cutting drum must be continually maintained and shall be replaced as warranted to provide a uniform pavement texture.
5. An integral pickup and conveying device to immediately remove milled material from the roadway and discharge the millings into a truck, all in one operation.
6. Safety devices such as reflectors, headlights, taillights, flashing lights and back up signals so as to operate safely in both day and night.
7. A means of effectively limiting the amount of dust escaping from the milling and removal operation in accordance with local, State, and Federal air pollution control laws and regulations.
8. Whenever the milling operations are being conducted between the hours of sunset and sunrise, the Contractor shall provide mobile lighting system(s).

When milling smaller areas or area where it is impractical to use the above-described equipment, the use of a smaller or lesser-equipped milling machine may be permitted when approved by the Owner's Representative and/or the Designer.

C. Sweeper Equipment. The Contractor shall provide a sufficient number of mechanical sweepers to ensure that the milled surface is free of millings and debris at the end of each day's milling operations. Each sweeper shall be equipped with a water tank, spray assembly to control dust, a pick-up broom, a dual gutter broom, and a dirt hopper. The sweepers shall be capable of removing millings and loose debris from the textured pavement.

D. Mobile Lighting for Milling and Sweeping Equipment. Whenever milling operations are being conducted between the hours of sunset and sunrise, the Contractor shall provide mobile lighting system(s) attached to each piece of mobile milling equipment, including milling machines and mechanical sweepers but shall not include trucks used to transport materials and/or personnel to the work zone or other vehicles that are continually moving in and out of the work zone.

1. Mobile lighting systems attached to milling equipment shall be in addition to Contractor's construction work zone lighting required for the Project.
2. Lighting attached to each machine shall be capable of providing a minimum of 1 fc measured 60 ft in front of and behind the equipment. Light fixtures shall be balloon-style or otherwise diffused to minimize glare. Flood lights without diffusers shall not be permitted.
3. No part of the mobile lighting system shall exceed a height 13 ft above the pavement. In areas with constrained vertical clearances the height may further be limited to accommodate the constraint.
4. Existing street, highway, or site lighting shall not eliminate the requirement for the Contractor to provide lighting.

E. Milling Operations. The Contractor shall coordinate milling and paving operations to minimize the exposure of milled surfaces to traffic. The Contractor shall ensure that milled surfaces are paved in a timely manner to avoid damage to the pavement structure. Any damage to the pavement structure resulting from extended exposure of the milled surface to traffic shall be repaired as directed by the Owner's Representative and/or the Designer at the Contractor's expense.

1. Under no circumstances shall the milled surface be left exposed to traffic for a period exceeding 7 calendar days. The Owner's Representative and/or the Designer may allow the Contractor to adjust the limits of milling production when necessary.
2. The existing pavement shall be removed to the average depth shown on the plans, in a manner that will restore the pavement surface to a uniform cross-section and longitudinal profile. The longitudinal profile of the milled surface shall be established using a 30-ft mobile ski, mobile string line, or stationary string line. The cross-slope of the milled surface shall be established by a second sensing device or by an automatic cross-slope control mechanism. The Contractor will be responsible for providing all grades necessary to remove the material to the proper line, grade, and typical cross-section shown on the plans. The requirement for automatic grade or slope controls may be waived by the Owner's Representative and/or the Designer in locations warranted by the situation, including intersections and closely confined areas.
3. The Owner's Representative and/or the Designer may adjust the average milling depth specified on the plans by ¾ in. during each milling pass at no additional payment to minimize delamination of the underlying pavement course or to otherwise provide a more stable surface. If delamination or exposure of concrete occurs when milling an HMA pavement course from an underlying Portland Cement Concrete pavement, the Contractor shall cease milling operations and consult the Owner's Representative and/or the Designer to determine whether to reduce the milling depth or make other adjustments to the operation.

F. Protection of Inlets and Utilities. Throughout the milling operation, protection shall be provided around existing catch basin inlets, manholes, utility valve boxes, and any similar structures. Any damage to such structures as a result of the milling operation is the Contractor's responsibility and shall be repaired at the Contractor's expense. To prevent the infiltration of milled material into the storm sewer system the Contractor shall take special care to prevent the milled material from falling into the inlet openings or inlet grates. Any milled material that falls into inlet openings or inlet grates shall be removed at the Contractor's expense.

G. Vertical Faces. All permanent limits of the milled area shall be sawcut or otherwise neatly cut by mechanical means to provide a clean and sound vertical face. No vertical faces, transverse or longitudinal, shall be left exposed to traffic. If any vertical face is formed in an area exposed to traffic a temporary paved transition with a maximum 12:1 slope shall be established. If the milling machine is used to temporarily transition the milled pavement surface to the existing pavement surface, the temporary transition shall be constructed at a maximum 12:1 slope.

H. Opening to Traffic. Prior to opening a milled area to traffic, the milled surface shall be thoroughly swept with a mechanical sweeper to remove all remaining millings and dust. This operation shall be conducted in a manner so as to minimize the potential for creation of a traffic hazard and to comply with local, State, and Federal air pollution control laws and regulations. Any damage to vehicular traffic as a result of milled material becoming airborne is the responsibility of the Contractor and shall be repaired at the Contractor's expense. Temporary pavement markings shall be placed in accordance with the Contract Documents.

I. Contractor Quality Control. The Contractor shall provide a Quality Control (QC) System adequate to ensure that all workmanship meets the quality requirements herein. The Contractor shall provide qualified QC personnel and perform QC inspection, data analysis, corrective action (when necessary), and documentation as outlined further below.

1. The milled surface shall provide a satisfactory riding surface with a uniform textured appearance. The milled surface shall be free from gouges, excessive longitudinal grooves and ridges, oil film, and other imperfections that are a result of defective equipment, non-uniform milling teeth, improper use of equipment, or otherwise poor workmanship. Any unsatisfactory surfaces produced shall be corrected by re-milling at the Contractor's expense.
2. The Contractor shall perform QC inspection of all work items as specified in MassDOT Standard Specifications Table 415.61-1. Inspection activities during milling of asphalt pavement may be performed by qualified Production personnel (e.g., Skilled Laborers, Foremen, Superintendents). However, the Contractor's QC personnel shall have overall responsibility for QC inspection. The Contractor shall not rely on the results of the Owner's Acceptance inspection for QC purposes. The Owner's Representative and/or Designer shall be provided the opportunity to monitor and witness all QC inspection.
3. The quality of each milled pavement surface will be inspected and evaluated on the basis of Lots and Sublots. A Lot is defined as an isolated quantity of work which is assumed to be produced by the same controlled process. A Lot shall constitute no greater than the entire milled surface area on the project completed within the same construction season using the same milling process.
4. The milled surface of each travel lane and/or parking aisle shall be divided into longitudinal Sublots of 500 ft. The Contractor shall perform a minimum of 1 random QC measurement within each Sublot with a 10-ft straightedge in the transverse direction across the milled surface. Additional selective QC measurements within each Sublot will be performed as deemed necessary by the QC personnel. All QC inspection results shall be recorded on NETTCP IRFs.
5. The milled surface shall have a texture such that the variation from the edge of the straightedge to the top of ridges between any 2 ridge contact points shall not exceed ⅛ in. The difference in height from the top of any ridge to the bottom of the valley adjacent to that ridge shall not exceed the values specified in MassDOT Standard Specification Table 415.61-1. Any point in the surface not meeting these requirements shall be corrected as directed by the Owner's Representative and/or the Designer at the Contractor's expense.
6. In isolated areas where surface delamination between existing HMA layers or a surface delamination of HMA on Portland Cement Concrete causes a non-uniform texture to occur, the straightedge surface measurement requirements stated in the preceding paragraph may be waived by the Owner's Representative and/or the Designer.

3.6 PATCHING

A. Areas of existing HMA pavement courses that are significantly distressed or unsound shall be removed and replaced with patches using new HMA. The location and limits of patching will be as identified in the plans or as directed by the Owner's Representative and/or the Designer.

B. Each existing pavement course determined to be unsound shall be removed to the full depth of the pavement course within a rectangular area. For each patch location equal to or

greater than 50 ft² (and having a minimum dimension of 4 ft) where the existing pavement courses are removed down to subbase, the subbase shall be compacted by mechanical means to not less than 95% of the maximum dry density of the subbase material as determined by AASHTO T 99 Method C at optimum moisture content. Each edge of the patch area shall be sawcut or otherwise neatly cut by mechanical means to provide a clean and sound vertical face. The vertical face of each edge shall be thoroughly coated with a hot poured joint sealer immediately prior to placing the HMA patching mixture.

C. Delaminated areas of existing pavement courses resulting from pavement milling shall be cut back neatly by mechanical means to the limits of any unsound material. After removing all unsound material, the underlying pavement surface within the patch limits shall receive a thorough tack coat at a rate of application in accordance Section 3.7 prior to placing the HMA patching mixture.

D. HMA patching mixture shall be the same mixture type as the existing pavement course being patched or as specified on the plans or as directed by the Owner's Representative and/or the Designer. The lift thickness of the patching mixture shall not exceed 4 times the nominal maximum aggregate size of the mixture. The patching mixture will be placed by hand or by mechanical means and shall match the thickness, grade, and cross-slope of the surrounding pavement. The HMA patching mixture shall be compacted using a steel wheel roller. For patch areas not large enough to permit use of a roller, compaction shall be accomplished using a mechanical tamper capable of achieving the required in-place density. The in- place density of the HMA patching mixture shall be not less than 90% of the maximum theoretical density of the mixture as determined by AASHTO T 209 (Method A). When the Contractor and Owner's Representative and/or Designer elect to test the in-place density of a patched area using a calibrated density gauge, the test data for the patched area shall be recorded on NETTCP TRFs.

3.7 SURFACE PREPARATION

A. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving. The Contractor shall ensure that it is in conformance with the required grade, cross-section, and in-place density. The compacted subbase shall not be frozen or have standing water.

B. Proof roll prepared base material surface, if applicable, to identify areas requiring removal and re-compaction, and to provide a uniform degree of compaction over the entire pavement area.

C. Do not begin paving work until deficient base material areas and utility trenches have been corrected and are ready to receive paving. Paving shall not be applied until the Designer inspects and approves the finished base.

D. When an existing surface or new base upon which the bottom course is to be placed contains unsatisfactory irregularities, in the Designer's judgment, such irregularities may be eliminated by an adequate placing and compaction of HMA mixture to furnish a surface with true contour and grade before placing any specified course of mixture.

E. When indicated on the plans, existing HMA pavement courses shall be milled and removed from the project by the Contractor in accordance with Section 3.5 and with Section 415 of the MassDOT Standard Specifications for Pavement Milling. Adjustments to milling depth shall be approved by the Designer and shall be used for consideration of the HMA pavement thickness measurements. Each vertical face of the milled pavement that meets new/existing pavement shall be thorough coats with a hot poured joint sealer.

F. Check all frames, covers, grates, water valve boxes and other miscellaneous castings that are located in the proposed pavement areas to ensure that all have been correctly positioned and set to the proper slope and elevation. All covers and grates shall be set flush with the required finished surface. All adjustments shall be made prior to placement of the surface course. No depressions or mounds will be permitted in the pavement to accommodate inaccuracies in the setting of castings. Hand placement of HMA along curbs, edging, or utilities after placement and compaction of the surface course shall not be permitted.

G. Leveling Course. Any HMA used for truing and leveling shall meet the requirements of the mix design methods and the requirements of MassDOT Standard Section 450.10 for the applicable mixtures. Leveling courses shall not be subject to density requirements. The thickness of the Leveling Course shall be measured off the interface with the existing milled or un-milled pavement surface. The leveling course shall be compacted with the same effort used to achieve placement and density of the test section. The truing and leveling course shall not exceed a nominal thickness of 1.5 inches.

H. Immediately before placing the hot mix asphalt, the underlying course shall be thoroughly cleaned of all dust and debris by a self-propelled sweeper. Areas inaccessible by power sweepers shall be broom swept until the pavement surface is clean. Extra care shall be required during fall leaf fall.

I. Tack Coat. Apply uniformly to surfaces to be paved.

1. Contact surfaces of manholes, structures, vertical pavement edges, etc. shall be painted with a thin, uniform tack coat just before the material is placed against them.
2. Tack coat is required on all surfaces to be paved; this includes leveling, base, or intermediate layers of HMA. Particular attention should be made during the application that the longitudinal joint areas be treated with no bare spots. Missing areas on the longitudinal joint area will require either re-application or localized hand work application. The existing surface shall be swept clean of all foreign matter and loose material using a mechanical sweeper and shall be dry before the tack coat is applied.
3. Tack Coat shall be applied by a pressure distributor. All nozzles on the distributor shall be open and functioning. All nozzles shall be turned at the same angle to the spray bar. The nozzles shall be offset at an angle from the spray bar to prevent the fan from one nozzle from interfering with the fan from another. Proper nozzle angle shall be as determined by the Manufacturer of the distributor spray bar. The spray bar shall be adjusted so that it is at the proper height above the pavement surface to provide a triple overlap spray for a uniform coverage of the pavement surface. A triple lap application requires that the nozzle spray patterns overlap one another such that every portion of the pavement receives spray from exactly three nozzles.
4. The tack distributor system shall be equipped with the following to control and monitor the application:
    a. System for heating the asphalt emulsion uniformly to specified temperature.
    b. Thermometer for measuring the asphalt emulsion temperature.
    c. Adjustable full circulation spray bar.
    d. Positive controls including tachometer, pressure gauge, and volume measuring device.
5. Tack coat application rates for specific surface conditions shall be in accordance with the following:
    a. On a new HMA surface, not opened to traffic, the emulsion application rate shall equal 0.06 to 0.08 gal/yd².

b. On an existing tight smooth pavement, the emulsion application rate shall equal 0.06 to 0.08 gal/yd².

c. On a milled surface the emulsion application rate shall equal 0.07 to 0.09 gal/yd².

d. On cement concrete base course, the emulsion application rate shall be equal to spray application for adjacent surface.

e. On new HMA patches the emulsion application rate shall equal 0.06 to 0.09 gal/yd². Allow tack coat to cure undisturbed before applying hot-mix asphalt paving.

6. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

7. Tack Coat shall be applied to cover a minimum of 95% of the pavement surface.

3.8 HOT-MIX ASPHALT TRANSPORTING, PLACING AND FINISHING

A. The trucks used to transport HMA to the field placement site shall have tight, clean, smooth metal beds. When necessary to maintain the required HMA temperature, trucks shall be equipped with insulated beds. The truck beds shall be evenly and lightly coated with an approved release agent meeting the requirements of MassDOT Standard Specification Section M3.01.6. Truck beds shall be free of kerosene, gasoline, fuel oil, solvent, or any other materials negatively impacting the HMA. The HMA shall be protected from foreign debris during transport.

B. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand to areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted.

C. HMA deliveries shall be scheduled so that placing and compacting of mixture is uniform with minimum stopping and starting of the paver.

D. Upon arrival, the mixture shall be placed to the full width by a hot mix asphalt paver. It shall be struck off in a uniform layer of such depth that, when the work is completed, it shall have the required thickness and conform to the grade and contour indicated. The speed of the paver shall be regulated to eliminate pulling and tearing of the hot mix asphalt mat. Unless otherwise permitted, placement of the mixture shall begin along the centerline of a crowned section or on the high side of areas with a one-way slope. The mixture shall be placed in consecutive adjacent strips having a minimum width of 10 feet except where edge lanes require less width to complete the area. The longitudinal joint in one course shall offset the longitudinal joint in the course immediately below by at least 6 inches however, the joint in the top layer shall be at the centerline of the pavement. Transverse joints in one layer shall be offset by at least 2 feet from transverse joints in the previous layer. The placement of the material along the longitudinal joint may be performed by setting the screed to overlap the first mat. The elevation of the screed above the surface of the first mat should be equal to the amount of roll-down expected during compaction of the new mat. The overlapped material shall be bumped by the lutes, if necessary, to optimize the density along the longitudinal joint. Under no circumstances should the overlapped material be broadcast across the mat. Excess material should be removed by hand. Transverse joints in adjacent lanes shall be offset a minimum of 10 feet.

E. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.

F. On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impractical, the mixture may be spread and luted by hand tools. When hand spreading is permitted, the mixture shall be distributed into place by means of hot shovels and spread with lutes in a loose layer of uniform density and correct depth. The use of rakes to spread the hot mix asphalt shall not be permitted. Loads shall not be dumped any faster than they can be properly handled by the shovelers and the shovelers shall not distribute the dumped load any faster than it can properly be handled by the luters. The luting shall be carefully and skillfully done to avoid segregation and so that, after the first passage of the roller over the luted mixture, no back patching will be necessary. Compaction must immediately follow hand spreading such that specification density is achieved while the mixture temperature is above the manufacturers recommended compaction temperature for the performance graded binder.

G. The mixtures shall be placed and compacted only at such times as to permit the proper inspection and checking by the Owner's Independent Testing Agency.

H. The mixtures shall only be placed in the work when they can be efficiently and satisfactorily placed, compacted, smoothed, and made uniform in accordance with these specifications. Unless otherwise permitted by the Owner's Representative and/or Designer for special particular conditions, only machine methods of placing shall be used.

I. No mixture shall be placed unless the breakdown, and intermediate rolling can be completed by the time the material has cooled to 195°F, or that minimum compaction temperature specified by the binder manufacturer and provided that the density and uniformity of the completed pavement attains specification compliance.

J. No traffic of any kind shall be permitted on the HMA intermediate or HMA base when dirt or any other foreign substance may be tracked thereon.

K. Immediately after any course is screeded and before roller compaction is started, the surface shall be checked, any irregularities adjusted, any accumulation from the screed removed by rake or lute, and all fat spots in any course removed and replaced with satisfactory materials. Irregularities in alignment and grade along outside edges shall be corrected by the addition or removal of mixture before the edges are rolled. Indiscriminate casting of mix on the new screeded surface, where irregularities are not evident, shall not be permitted.

L. All hot mix shall be placed and compacted in such a manner as to ensure a continuous bond between the tacked hot mix pavement surfaces and obtain the required density.

M. No vehicular traffic or loads shall be permitted on newly completed HMA until adequate stability has be attained and the material has cooled to a temperature of 140°F or less.

3.9 JOINTS

A. Construct joints to ensure a continuous bond between adjoining paving sections and to obtain the required density. Construct joints free of depressions, with same texture and smoothness and grade as other sections of hot-mix asphalt course. When abutting a previously placed lane, the longitudinal joint should be rolled first followed by the regular rolling procedure.

1. Clean contact surfaces and apply hot poured joint sealer to joints.
2. Longitudinal Joints.

a. All longitudinal joints shall be constructed with the first paver pass in a neat straight line. Deviation from trueness will negate the ability to form a properly compacted longitudinal joint.

b. The paver screed may be equipped with a Longitudinal Notched - Wedge Joint or Straight Wedge Joint paver attachment and screed mounted roller attachment when placing HMA pavement courses. Use the Notched Wedge Joint for thicknesses of 1.5 inches or greater and use the Straight Wedge Joint for thicknesses less than 1.5 inches. The notched wedge joint shall include a variable notched vertical edge (the notch vertical height to be equal to the mixture's maximum aggregate size). The sloped surface of the diagonal wedge joint shall not exceed a 6:1 slope. Prior to placing the adjacent paver pass, all joint contact surfaces shall be given a coat of hot poured joint sealer prior to placing any fresh mixture against the joint. Hot applied joint filler shall not be applied when a wedge joint is used. A tack coat shall be applied to the entire surface of the wedge joint.

c. Vertical butt joints which are not constructed straight, are not constructed with an edge restraining device (either a commercial paver screed attachment or by dropping the end gate down to the surface) or are damaged (or otherwise defective) shall be cut back 3 inches to expose a clean, sound surface for the full depth of the course and all contact surfaces shall be given a coat of hot poured joint sealant prior to placing any fresh mixture against the joint.

d. Offset longitudinal joints, in successive courses, a minimum of 12 inches.

e. All longitudinal joint edges on surface courses shall be treated with hot applied joint filler, regardless of location.

f. When longitudinal joints abut edges such as curbs, gutters, manholes, etc., a tack coat surface shall be applied over the entire joint.

3. Transverse Joints.

a. The roller shall not pass over the unprotected end of the freshly laid mixture except when necessary to form a transverse joint. When necessary to form a transverse joint, it shall be made by means of placing a bulkhead or by tapering the course, in which case the edge shall be cut back to its full depth and width on a straight line to expose a vertical face. In both methods, all contact surfaces shall be given a coat of hot poured joint sealer before placing any fresh mixture against the joint.

b. Offset transverse joints, in successive courses, a minimum of 24 inches.

4. Longitudinal and transverse joints shall have an in-place density when measured by the average of three 6-inch cores of between 90% to 98% of maximum theoretical.

5. Construct transverse joints at each point where paver ends a day's work and resumes work at a subsequent time. Construct these joints using either "bulkhead" or "papered" method according to AI MS-22, for both "Ending a Lane" and "Resumption of Paving Operations."

6. At the start/end of new HMA meeting existing HMA, the existing pavement shall be sawcut. Sawcut faces shall be coated with hot applied joint sealer prior to HMA placement.

7. If traffic is to be carried over any traverse joints before HMA completion, a temporary pavement joint of a maximum 12:1 slope shall be constructed. Reheating of the joint will not be permitted.

3.10 COMPACTION

A. The mixture shall be thoroughly and uniformly compacted by rolling. Equipment may include steel wheeled rollers, vibratory rollers, oscillation rollers, or pneumatic-tired rollers. The surface shall be compacted as soon as possible when the mixture has attained sufficient stability so that the rolling does not cause undue displacement, cracking or shoving. The sequence of rolling operations and the type of rollers used shall be at the discretion of the Contractor so that the required compaction and surface texture are consistently attained while the mixture is in a workable condition. When possible, the Contractor is encouraged to use pneumatic or oscillation rollers. Rolling shall be initiated with the drive roll or wheel towards the paving machine. When rolling on steep grades, the previous procedure may need to be altered. The Contractor shall provide the proper number of rollers to achieve the target in-place density and course thickness.

B. The speed of the roller shall, at all times, be sufficiently slow and of uniform speed to avoid displacement of the hot mixture and be effective in compaction. Any displacement occurring because of reversing the direction of the roller, or from any other cause, shall be corrected at once. Rollers shall not be permitted to stop on the mat except to reverse direction or refill water.

C. Rolling shall continue until the surface is of uniform texture, true to grade and cross section, and the required field density is obtained. The number of rollers and passes required shall be governed by the compaction results; however, at least two rollers shall be provided for each paver employed on the paving operation. Each roller shall be operated by a competent, experienced roller operator and shall be kept in as nearly continuous operation as practicable while work is underway. A plate shall be attached to each roller showing the ballasted and unballasted weight per length-width of tread.

D. To prevent adhesion of the mixture to the steel roller, the drums or shall be kept properly moistened, cocoa mats kept clean and scrapers used, but excessive water will not be permitted. Pneumatic rollers shall be operated on adjacent pavement surfaces to get the tires warm to hot from friction, then moved to the fresh mat.

E. In areas not accessible to the roller, the mixture shall be thoroughly compacted with hand tampers and vibratory plate compactors.

F. Any mixture that becomes loose and broken, mixed with dirt, contains check-cracking, or in any way defective shall be removed and replaced with fresh hot mixture and immediately compacted to conform to the surrounding area. This work shall be done at the Contractor’s expense. Skin patching shall not be allowed.

G. Along any adjoining edge such as curb, gutter or an adjoining pavement, and after the HMA is placed by the paver, just enough of the hot HMA shall be placed by hand method to fill any space left open. These joints shall be properly ‘set up’ with the back of a lute at the proper height and level to receive the maximum compaction. Any areas where the rollers cannot access shall be hand tamped or plate compacted.

H. Breakdown Rolling. Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Correct laydown and rolling operations to comply with requirements.

I. Intermediate Rolling. Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted to the required field density.

J. Finish Rolling. Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.

K. Edge Shaping. While the surface is being compacted and finished, the Contractor shall carefully trim the outside edges of the pavement to the proper alignment. Edges so formed shall be beveled while still hot with the back of a lute or smoothing iron and thoroughly compacted by tampers or by other satisfactory methods.

L. Protection. After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.

M. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

3.11 HOT MIX ASPHALT BERM AND CURB – NOT USED

3.12 HOT MIX ASPHALT WALKWAY SURFACES

A. Hot mix asphalt shall meet the relevant requirements of hot mix asphalt Superpave materials in this specification.

B. The hot mix asphalt walk surface shall be laid in two (2) courses to a depth after rolling as indicated in the Contract Drawings. Each course shall be one-half (1/2) the total depth of walkway pavement. The bottom course surface after rolling shall be parallel to the proposed grade of the finished surfaces. The top course surface after rolling shall be at the finished grade as indicated on the Contract Drawings.

1. The hot mix asphalt shall be placed to the full width by a self-propelled sidewalk paver and shall be struck off in a uniform layer of such depth that, when the work is completed, it shall have the required thickness and conform to the grades and surface contour required.
2. The hot mix asphalt may be spread and luted by hand tools. When hand spreading is permitted, the mixture shall be distributed into place from wheelbarrows by means of hot shovels and spread with lutes in a loose layer of uniform density and correct depth. The use of rakes to spread the hot mix asphalt shall not be permitted. Loads shall not be dumped any faster than they can be properly handled by the shovelers and the shovelers shall not distribute the dumped load any faster than it can properly be handled by the luters. The luting shall be carefully and skillfully done to avoid segregation and so that, after the first passage of the roller over the luted mixture, no back patching will be necessary. Compaction must immediately follow hand spreading such that specification density is achieved while the mixture temperature is above the manufacturers recommended compaction temperature for the performance graded binder.
3. Rolling. The surface shall be rolled with a self-propelled tandem roller weighing not less than 1-1/2 tons and not more than 5 tons. In places not accessible to a power roller, compaction shall be obtained by means of mechanical rammers or by hand tampers weighing not less than 50 pounds and having a tamping face not exceeding 100 square inches.

C. The dimensions, cross slope, grades and tolerances of the pedestrian walkway shall be in conformance with the standard construction details.

D. The cross slope of the finished walkway shall not exceed 1.5%.

3.13 SEALCOATING – NOT USED

3.14 INSTALLATION TOLERANCES

A. Accessibility: Comply with requirements of Massachusetts Architectural Access Board and ADAAG requirements. Remove and replace paving that does not meet required tolerances when measured with a 2 foot straight edge.

B. Pavement Thickness: Compact each course to produce the thickness indicated within the following tolerances:

1. Base Course: Plus or minus 3/8 inch.
2. Surface Course: Plus 1/4 inch, no minus.

C. Pavement Surface Smoothness: Compact each course to produce a surface smoothness within MHD Specification tolerances as determined by using a 10-foot straightedge applied transversely or longitudinally to paved areas.

3.15 OPENING TO TRAFFIC

A. No vehicular traffic or loads shall be permitted on the newly completed pavement until all of the following conditions are met:

1. Adequate stability has been attained.
2. The material has cooled sufficiently to prevent distortion or loss of fines.
3. The pavement has cooled sufficiently to an internal temperature of 140 degrees F or less.

B. If the climatic or other conditions warrant, or if the PGAB manufacturer recommends, the period of time before opening to traffic may be extended at the discretion of the Owner’s Representative and/or Designer.

3.16 DISPOSAL

A. Except for material indicated to be recycled, remove excavated materials from the Project site, and legally dispose of them in an EPA-approved landfill.

End of Section

Section 32 13 13.1

CONCRETE PLAZA & WALKWAY PAVEMENT

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01, GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.2 DESCRIPTION OF WORK

A. Provide all equipment and materials and do all work necessary to construct the Portland cement concrete paving work, complete, as indicated on the Drawings and as specified. Portland cement concrete paving shall include but not be limited to: concrete walks, sidewalks, accessible ramps, service area pads, and detectable warning surfaces.

1.3 RELATED SECTIONS

A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that directly relate to work of this Section include, but are not limited to:

1. Section 01 40 00, QUALITY REQUIREMENTS
2. Section 31 20 00, EARTH MOVING
3. Section 03 30 01, CAST-IN-PLACE CONCRETE – SITEWORK
4. Section 07 92 00, JOINT SEALANTS
5. Section 32 12 16, ASPHALT
6. Section 32 14 13, CONCRETE UNIT PAVING
7. Section 32 16 00, GRANITE CURBING

1.4 REFERENCES

A. Comply with applicable requirements of the following standards. Where these standards conflict with other specified requirements, the most restrictive shall govern:

1. American Concrete Institute (ACI):

301	Specifications for Structural Concrete for Buildings
305R	Hot Weather Concreting
306R	Cold Weather Concreting
325.9R	Guide for Construction of Concrete Pavements and Concrete Bases.

2. American Society for Testing and Materials (ASTM):

A 615	Deformed and Plain Billet - Steel Bars for Concrete Reinforcement
C 33	Concrete Aggregates
C 94	Ready-Mixed Concrete

C 143	Slump of Portland Cement Concrete
C 150	Portland Cement
C 171	Sheet Materials for Curing Concrete
C 231	Air Content of Freshly Mixed Concrete by the Pressure Method
C 260	Air Entraining Admixtures for Concrete
C 309	Liquid Membrane-Forming Compounds for Curing Concrete
C 494	Chemical Admixtures for Concrete
C 920	Elastomeric Joint Sealants
C 962	Guide for Use of Elastomeric Joint Sealants
D 226	Asphalt-Saturated Organic Roofing Felt for Use in Membrane Waterproofing and Built-Up Roofing
D 1557	Moisture - Density Relations of Soils and Soil Aggregate Mixtures Using 10 lb. (4.54-kg) Rammer and 18-in. (457 mm) Drop
D 1752	Preformed Sponge Rubber and Cork Expansion Joint Fillers f or Concrete Paving and Structural Construction
E 1980	Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low-Sloped Opaque Surfaces

Appendix to Part 1191 Accessibility Guidelines for Buildings and Facilities

3. Commonwealth of Massachusetts Highway Department (MHD):

   Specifications Standard Specifications for Highways and Bridges

4. Corps of Engineers (COE):

   CRD-C 621 Specification for Nonshrink Grout: Hardened State Volume Change

5. Federal Specifications (Fed Spec.):

   TT-S-00227 Sealing Compound: Elastomeric Type, Multi- Component (For Caulking, Sealing, and Glazing in Buildings and other Structures)

1.5 QUALITY ASSURANCE

A. Manufacturer Qualifications: Manufacturer of ready-mixed concrete products who complies with ASTM C 94/C 94M requirements for production facilities and equipment.

   1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities."

B. Testing Agency Qualifications: An independent agency qualified according to ASTM C 1077 and ASTM E 329 for testing indicated, as documented according to ASTM E 548.

1. Personnel conducting field tests shall be qualified as ACI Concrete Field Testing Technician, Grade 1, according to ACI CP-01 or an equivalent certification program.

C. ACI Publications: Unless otherwise specified, work and materials for construction of the Portland cement concrete paving shall conform to ACI 325.9R.

D. Work, materials, and color of the handicap ramp paving shall conform to applicable sections of Americans with Disabilities Act (ADA) Accessibility Guidelines for Buildings and Facilities.

E. Paving work, base course etc., shall be done only after excavation and construction work which might injure them have been completed. Damage caused during construction shall be repaired before acceptance.

F. Existing paving areas shall, if damaged or removed during course of this project, be repaired or replaced under this section of the specification. Workmanship and materials for such repair and replacement, except as otherwise noted, shall match as closely as possible those employed in existing work.

G. Pavement, base, or subbase shall not be placed on a muddy or frozen subgrade.

1.6 PRECONSTRUCTION MOCK-UPS

A. General

1. Schedule mock-up casting for acceptance 30 days prior to casting of concrete surfaces represented by the mockups.
2. Locate mock-up panels in non-public areas accepted by the Architect.
3. Continue to cast mock-ups until acceptable mock-ups area produced. Accepted mock-ups shall be the standard for color, texture, and workmanship for the work.
4. Mock-up sequence of forming, placing, form removal, curing, and finishing shall be reviewed and accepted by the Architect.
5. Mock-up formwork shall be inspected and accepted by the Architect before placing of concrete.
6. Use the same concrete mixes and placement procedures, accepted in mock-ups, in the final work, unless otherwise directed by the Architect.
7. Protect accepted mock-ups from damage until completion and acceptance of the work represented by the mock-up.
8. Remove mock-up panels from site at completion of project, as directed by the Architect.
9. Separate exposed aggregate concrete mockup shall be cast prior to work on the stage in the building courtyard.

B. Construct mock-up panels or areas as indicated to demonstrate the ability to cast concrete for concrete paving to achieve shape, color, jointing and textured finish required. Mock-ups shall include or meet the following requirements:

1. Provide full scale mock-up panels: 4’ x 8’ panel showing broom finish and jointing.

2. Provide mock-ups simulating actual design and execution conditions for concrete mix materials, formwork, placing sequence, form removal, curing, finishing, and methods and materials of stain removal and correction of defective work.
3. On mock-ups where directed by the Architect, provide minimum of three variation of mix color to be used in the repair of defective work, in order to determine acceptable color and texture match.
4. Demonstrate in the construction of the mock-up formwork the sealer material, form release agent, and curing materials and methods to be used.

C. Source of Materials. Utilize the same source, stock, or brand of concrete materials for each class or mix of concrete which is to be exposed. Do not interchange materials or mixes until an additional mock-up shows that uniformity in finish texture and color, as compared to original mock-up will be maintained. If necessary, obtain and stockpile materials in sufficient quantity to ensure continuity and uniformity.

1.7 SUBMITTALS

A. Description of Methods and Sequence of Placement. For each type of specially-finished concrete provide description of methods and sequence of placement.

B. Submit manufacturer's product data for the following including color options where applicable:
1. Form release agent.
2. Curing material
3. Preformed joint filler, per Section 07 92 00
4. Non-sag joint sealant.
5. Welded wire reinforcement (for plaza pavements)
6. Exposed Aggregate Concrete seeded aggregate including sieve analysis and color options

C. Submit samples of the following:
1. Preformed joint filler.
2. Non-sag joint sealant.
3. Seeding Aggregate; 5 lb. bag each proposed aggregate, submitted prior to construction of mockups

D. Design Mixtures: For each concrete pavement mixture. Include alternate mixture designs when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

E. Material Certificates: Signed by manufacturers certifying that each of the following materials complies with requirements:
1. Cementitious materials.
2. Steel reinforcement and reinforcement accessories.
3. Admixtures.
4. Curing compounds.

5. Bonding agent or epoxy adhesive.

1.8 TESTING AND INSPECTION

A. The Owner reserves the right to inspect and test paving and associated work in accordance with Section 01 40 00, QUALITY REQUIREMENTS.

PART 2 - PRODUCTS

2.1 AGGREGATE BASE COURSE

A. Material for aggregate base course shall be a graded, granular, non-frost susceptible, free- draining material, consisting of either durable stone and coarse sand or of blast furnace slag, practically free from loam and clay, and which can be readily compacted to form a stable foundation.

1. Material shall conform to MHD Specifications Section M1.03.0 Type b, with less than 8% by weight passing No. 200 sieve.

STEEL REINFORCEMENT – WHERE NOTED ON DRAWINGS, CONCRETE SIDEWALKS HAVE NO REINFORCEMENT PER CITY OF WORCESTER STANDARDS, SEE SECTION 321313

B. Steel reinforcing bars shall conform to the following requirements:

1. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (Grade 420); deformed.
2. Galvanized Reinforcing Bars: ASTM A 767/A 767M, Class II zinc coated, hot-dip galvanized after fabrication and bending; with ASTM A 615/A 615M, Grade 60 (Grade 420) deformed bars.

C. Welded wire fabric reinforcement shall conform to the following acceptable requirements. Fabric reinforcement shall be furnished in flat sheets, sized as indicated on the Drawings. Fabric reinforcement in rolls will not be permitted.

1. Plain-Steel Welded Wire Reinforcement: ASTM A 185, fabricated from as-drawn steel wire into flat sheets.

D. Joint Dowel Bars: Plain steel bars, ASTM A 615/A 615M, Grade 60 (Grade 420). Cut bars true to length with ends square and free of burrs.

E. Tie Bars: ASTM A 615/A 615M, Grade 60 (Grade 420), deformed.

F. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded wire reinforcement, and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete of greater compressive strength than concrete, and as follows:

1. Equip wire bar supports with sand plates or horizontal runners where base material will not support chair legs.

2.2 PORTLAND CEMENT CONCRETE

A. Portland cement concrete for pavements and slabs shall be air-entrained type with a maximum water-cement ratio of 0.50 conforming to ACI 325.9R. Minimum compressive strengths at 28 days shall be as follows: Flexural strength with third point loading - 650 psi; compressive strength - 4000 psi.

1. Concrete shall be air-entrained type, conforming to ASTM C 94. Air content by volume shall be 6% + 1%, and shall be tested in accordance with ASTM C 231.
2. Concrete slump shall be no less than 2 in. nor greater than 4 in., determined in accordance with ASTM C 143.
3. Cement shall be Portland cement, conforming to ASTM C 150, Type I or II. Only one color of cement, all of the same manufacturer, shall be used fothe work.
4. Fine and coarse aggregates shall be recycled porcelain, concrete, stone, or other recycled content material conforming to requirements of mix design.
5. Concrete shall contain a water reducing agent to minimize cement and water content of the concrete mix at the specified slump. Water reducing agent shall conform to ASTM C 494.
6. No calcium chloride or admixtures containing calcium chloride shall be added to the concrete. No admixtures other than those specified shall be used in the concrete without the specific written permission of the Architect in each case.

2.3 CHEMICAL ADMIXTURES

A. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and to contain not more than 0.1 percent water-soluble chloride ions by mass of cementitious material.
   1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
   2. Retarding Admixture: ASTM C 494/C 494M, Type B.

2.4 CURING MATERIALS

A. Curing shall be by moist curing or by use of curing compound.

B. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. (305 g/sq. m) dry.

C. Moisture-Retaining Cover: Curing paper shall be nonstaining, fiber reinforced laminated kraft bituminous product conforming to ASTM C 171. Four mil polyethylene sheeting may be substituted for curing paper.

D. Curing Compounds, Sealers, and coatings: Water-based.
   1. Toxicity/IEQ: Zero VOC. E. Water: Potable.

2.5 EXPANSION JOINTS

A. Unless otherwise indicated on the Drawings, expansion joints shall be located 30 ft. o.c., maximum and at all fixed, vertical faces.

B. Expansion joint filler shall be preformed, nonbituminous type joint filler conforming to ASTM D 1752, Type II, similar to Sealtight Cork Expansion Joint Filler, manufactured by W.R. Meadows, Inc., Elgin, IL 60120, or approved equal.
   1. Premolded filler shall be one piece for the full depth and width of the joint leaving a sealant recess as indicated.
   2. Use of multiple pieces of lesser dimensions to make up required depth and width of joint will not be permitted.

3. Except as otherwise noted on the Drawings, joint filler shall be a maximum 3/8 in. wide.

2.6 CONTROL JOINTS

A. Control joints indicated to be sawn shall be made by saw cutting concrete slab after concrete is finished and when the surface is stiff enough to support the weight of workmen without damage to the slab. Saw blade shall cut into slab at least 1 in., but in no case less than 25% of slab depth. Do not overcut at joints-see drawings for jointing pattern in plazas.

2.7 EXPOSED CONCRETE SEEDED AGGREGATE

A. Seeded Aggregate: Selected, hard, and durable; washed; free of materials with deleterious reactivity to cement or that cause staining; from a single source, with gap-graded coarse aggregate as follows:
   1. 3/8” Washed by Dry Bridge Sand & Stone, Inc. 471 Dry Bridge Rd. North Kingston, RI 02852 (401) 295-2147 or approved equal. Color tones to be in the blue/tan/native mix. Submit sample options for approval.

2.8 GROUT

A. Grout shall be mixed in the proportions of one part Portland cement to two parts sand, by volume. Only sufficient water shall be used to enable grout to barely hold its shape when squeezed into a ball in the hand. Sand for grout shall be "Fine Aggregate", conforming to ASTM C 33.

B. Nonshrink grout shall be pre-mixed non-shrinking, high strength grout. Compressive strength in 28 days shall be 5,000 psi minimum, but in no case less than the specified strength of the adjacent concrete. Manufacturer shall provide evidence that the material meets the requirements of the COE CRD-C 621 (558). Grout permanently exposed to view shall be nonoxidizing; metallic grout may be used in other locations.
   1. Nonshrink grout shall be one of the following, or approved equal:

MANUFACTURER	PRODUCT
Gifford-Hill Co.	Supreme
Master Builders Co.	Embeco
U.S. Grout Corporation	Five Star Grout

2.9 SEALANT

A. Sealant for sealing of control joints and expansion joints in concrete walks shall be a two component polyurethane based sealant conforming to ASTM C 920 as specified in Section 07 92 00, JOINT SEALANTS.

2.10 BOND BREAKER

A. Bond breaker shall be asphalt felt conforming to ASTM D 226, Type I or 6 mil polyethylene sheeting.

PART 3 - EXECUTION

3.1 PREPARATION OF SUBGRADE

A. Areas to be paved will be compacted and brought to subgrade elevation under Section 31 20 00, EARTH MOVING before work of this section is performed. Final fine grading, filling, and compaction of areas to receive paving, as required to form a firm, uniform, accurate, and unyielding subgrade at required elevations and to required lines, shall be done under this Section.

B. Existing subgrade material which will not readily compact as required shall be removed and replaced with satisfactory materials. Additional materials needed to bring subgrade to required line and grade and to replace unsuitable material removed shall be material conforming to this Section.

C. Subgrade of areas to be paved shall be recompacted as required to bring top 8 in. of material immediately below gravel base course to a compaction at optimum moisture of at least 95% of maximum density, as determined by ASTM D 1557. Subgrade compaction shall extend for a distance of at least 1 ft. beyond pavement edge.

1. Field testing shall be conducted to determine in-place density, accompanied by visual inspection of the compaction methods being used.

D. Excavation required in pavement subgrade shall be completed before fine grading and final compaction of subgrade are performed. Where excavation must be performed in completed subgrade, subbase, base, or pavement, subsequent backfill and compaction shall be performed as directed by the Architect as specified in Section 31 20 00, EARTH MOVING. Completed subgrade after filling such areas shall be uniformly and properly graded.

E. Areas being graded or compacted shall be kept shaped and drained during construction. Ruts greater than or equal to 2 in. deep in subgrade, shall be graded out, reshaped as required, and recompacted before placing pavement.

F. Materials shall not be stored or stockpiled on subgrade.

G. Disposal of debris and other material excavated under this section, and material unsuitable for or in excess of requirements for completing work of this section shall be disposed of off- site.

H. Prepared subgrade will be inspected by the Architect. Subgrade shall be approved by the Architect before installation of gravel base course. Disturbance to subgrade caused by inspection procedures shall be repaired under this section of the specification.

3.2 AGGREGATE BASE COURSE

A. Aggregate base course for paving and the spreading, grading, and compaction methods employed shall conform to standard requirements for usual base course of this type for first class road work, and the following:

1. MHD Specifications Section 402, "Dense-Graded Crushed Stone for Sub-Base".

B. Width of base course shall be greater than or equal to the width of pavement surface, if continuous lateral support is provided during rolling, and shall extend at least 2 x base thickness beyond edge of the course above, if not so supported.

C. Aggregate material shall be applied in lifts less than or equal to 6 in. thick, compacted measure. Each lift shall be separately compacted to specified density, using a 6 ton smooth drum vibratory roller equivalent to a 6 ton static roller, or an approved equivalent. Smaller areas or areas impossible to reach with large drum rollers shall be compacted to specified density using a vibrating plate compactor.

1. Material shall be placed adjacent to wall, manhole, catch basin, and other structures only after they have been set to required grade and level.
2. Rolling shall begin at sides and progress to center of crowned areas, and shall begin on low side and progress toward high side of sloped areas. Rolling shall continue until material does not creep or wave ahead of roller wheels.
3. Surface irregularities which exceed 1/2 in. as measured by means of a 10 ft. long straightedge, shall be replaced and properly recompacted.

D. Base course shall be compacted at optimum moisture content to not less than 95% of maximum density as determined by ASTM D 1557.

E. Subgrade and base course shall be kept clean and uncontaminated. Less select materials shall not be permitted to become mixed with gravel. Materials spilled outside pavement lines shall be removed and area repaired.

F. Portions of subgrade or of construction above which become contaminated, softened, or dislodged by passing of traffic, or otherwise injured, shall be cleaned, replaced, or otherwise repaired to conform to the requirements of this specification before proceeding with next operation.

3.3 STEEL REINFORCEMENT

A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

B. Before being placed in position, reinforcing for reinforced concrete shall be thoroughly cleaned of loose mill and rust scale, dirt, ice, and other foreign material which may reduce the bond between the concrete and reinforcing. Where there is delay in placing concrete after reinforcement is in place, bars shall be reinspected and cleaned when necessary.

C. Any bar showing cracks after bending shall be discarded.

D. Unless otherwise indicated on the Drawings, reinforcing shall extend within 2 in. of formwork and expansion joints. Reinforcing shall continue through control joints. Adjacent sheets of fabric reinforcing shall lap 6 in.

E. After forms have been coated with form release agent, but before concrete is placed, reinforcing steel anchors shall be securely wired in the exact position called for, and shall be maintained in that position until concrete is placed and compacted. Chair bars and supports shall be provided in a number and arrangement satisfactory to the Architect.

F. Install welded wire reinforcement in lengths as long as practicable only in locations indicated on Drawings. Lap adjoining pieces at least one full mesh, and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.

3.4 PORTLAND CEMENT CONCRETE PAVING

A. Paving mix, equipment, methods of mixing and placing, and precautions to be observed as to weather, condition of base etc., shall meet the requirements of ACI 325.9R. Pavement shall be constructed in accordance with the Drawings.

B. The Architect shall be notified of concrete placement sufficiently in advance of start of operation to allow his representative to complete preliminary inspection of the work, including subgrade, forms, and reinforcing steel, if used.

C. Normal concrete placement procedures shall be followed. Concrete shall arrive at the jobsite so that no additional water will be required to produce the desired slump. When conditions develop that required addition of water to produce the desired slump, permission of the Architect must be obtained. The concrete shall be transported from the mixer to its place of deposit by a method that will prevent segregation or loss of material.

D. Work shall not be performed during rainy weather or when temperature is less than 40º F. (4.4º C).

E. Adjacent work, etc., shall be protected from stain and damage during entire operation. Damaged and stained areas shall be replaced or repaired to equal their original conditions.

F. Existing concrete, earth, and other water-permeable material against which new concrete is to be placed shall thoroughly damp when concrete is placed. There shall be no free water on surface.

G. Concrete which has set or partially set before placing shall not be employed. Re-tempering of concrete will not be permitted.

H. Concrete shall be thoroughly spaded and tamped to secure a solid and homogeneous mass, thoroughly worked around reinforcement and into corners of forms.

I. When joining fresh concrete to concrete which has attained full set, latter shall be cleaned of foreign matter, and mortar scum and laitance shall be removed by chipping and washing. Clean, roughened base surface shall be saturated with water, but shall have no free water on surface. A coat of 1:1 cement-sand grout, approximately 1/8 in. thick, shall be well scrubbed into thoroughly dampened concrete base. New concrete shall be placed immediately, before grout has dried or set.

3.5 FINISHING

A. Concrete flatwork surfaces shall be screeded off, bullfloated, power or hand floated, troweled and finished true to line and grade, and free of hollows and bumps. Surface shall be dense, smooth, and at exact level and slope required.

1. Finished concrete surface for exposed concrete pavement shall be wood-floated and steel troweled to a smooth surface. Surface shall not deviate more than 1/8 in. in 10 ft.

B. Unless otherwise indicated, horizontal surfaces of concrete surfaces which will be exposed shall be given a medium broomed finish, with direction of grooves in concrete surface perpendicular to length of concrete band, slab, or pad. After concrete has set sufficiently to prevent coarse aggregate from being torn from surface, but before it has completely set, brooms shall be drawn across it to produce a pattern of small parallel grooves. Broomed surface shall be uniform, with no smooth, unduly rough or porous spots, or other irregularities. Coarse aggregate shall not be dislodged by brooming operation. Confirm direction of brooming with Landscape Architect prior to commencement.

C. Immediately following finishing operations, arises at edges and both sides of expansion joints shall be rounded to a 1/4 in. radius.

D. Where finishing is performed before end of curing period, concrete shall not be permitted to dry out, and shall be kept continuously moist from time of placing until end of curing period, or until curing membrane is applied.

3.6 SEEDED SURFACE EXPOSED-AGGREGATE FINISH

A. Prior to the concrete placing operation, all select seeding aggregate shall be washed thoroughly so that it is free of all dust, dirt, and clay particles. The aggregate shall be in a damp condition but without free surface water at the time of seeding application. There shall be sufficient select aggregate on hand to complete the seeding once it has started.

1. Work shall be planned so that the concrete-placing and aggregate-seeding procedures are coordinated with the capabilities of the washing and brushing crew.

B. The seeding operation shall start immediately after the placement of concrete as described above. The select aggregate shall be carefully and uniformly seeded by suitable means so that the entire surface is completely covered with one layer of stone. Stacked stone and flat and slivery particles shall be removed at this time. The aggregate shall be embedded by suitable means, and float finished to entirely embed aggregate with mortar cover of 1/16 inch (1.6 mm). Care shall be taken not to overembed and deform the surface. Under no circumstances shall areas lacking sufficient mortar be filled with small quantities of the base concrete mix.

1. Spray-apply chemical surface retarder to pavement according to manufacturer's written instructions.
2. Cover pavement surface with plastic sheeting, sealing laps with tape, and remove sheeting when ready to continue finishing operations.
3. Without dislodging aggregate, remove excess mortar by lightly brushing surface with a stiff, nylon-bristle broom.

4. Fine-spray surface with water and brush. Repeat water flushing and brushing cycle until cement film is removed from aggregate surfaces to depth required.

C. Vertical variance within exposed aggregate finish shall not exceed 1/8 in.

3.7 CURING

A. It is essential that concrete be kept continuously damp from time of placement until end of specified curing period. It is equally essential that water not be added to surface during floating and troweling operations, and not earlier than 24 hours after concrete placement. Between finishing operations surface shall be protected from rapid drying by a covering of waterproofing paper. Surface shall be damp when the covering is placed over it, and shall be kept damp by means of a fog spray of water, applied as often as necessary to prevent drying, but not sooner than 24 hours after placing concrete. None of the water so applied shall be troweled or floated into surface.

B. Concrete surfaces shall be cured by completely covering with curing paper or application of a curing compound.

1. Concrete cured using waterproof paper shall be completely covered with paper with seams lapped and sealed with tape. Concrete surface shall not be allowed to become moistened between 24 and 36 hours after placing concrete. During curing period surface shall be checked frequently, and sprayed with water as often as necessary to prevent drying, but not earlier than 24 hours after placing concrete.
2. If concrete is cured with a curing compound, compound shall be applied at a rate of 200 sq. ft. per gallon, in two applications perpendicular to each other.
3. Curing period shall be seven days minimum.

3.8 EXPANSION JOINTS

A. Expansion joints (isolation joints) shall be 3/8 in. wide and shall be located 30 ft. o.c unless otherwise indicated on the Drawings and at places where pavement meets other vertical faces. Expansion joint shall be formed in the concrete to required width with preformed joint filler in place. Joint filler shall extend the full width and depth of the slab. Joint filler shall extend the full length of the expansion joint.

1. For concrete pavements, depth of joint filler shall be as required to form a 1-1/4 in. deep sealant and backer rod recess below finished concrete surface.

3.9 CONTROL JOINTS

A. Control joints indicated shall be sawn by using a diamond blade concrete power saw. Joint shall be made after concrete is finished and when the surface is stiff enough to support the weight of workmen without damage to the slab. Saw shall cut into slab at least 1 in., but in no case less than 25% of slab depth.

1. Saw cut joints shall be sawn flush to vertical surfaces.

2. Unless otherwise indicated on the Drawings, control joints in pedestrian pavements (sidewalks) shall be located 10 ft. o.c. maximum.

3.10 TACTILE WARNING SURFACE – SEE SECTION 321726 – TACTILE WARNING SURFACING FOR INFORMATION AND DRAWINGS FOR LOCATIONS.

3.11 COLD WEATHER CONCRETING

A. Materials for concrete shall be heated when concrete is mixed, placed, or cured when the mean daily temperature is below 40ºF. or is expected to fall to below 40ºF. within 72 hours, and the concrete after placing shall be protected by covering, heat, or both.

B. Details of handling and protecting of concrete during freezing weather shall be subject to the approval and direction of the Architect. Procedures shall be in accordance with provisions of ACI 306R.

3.12 HOT WEATHER CONCRETING

A. Concrete just placed shall be protected from the direct rays of the sun and the forms and reinforcement just prior to placing shall be sprinkled with cold water. Every effort shall be made to minimize delays which will result in excessive mixing of the concrete after arrival on the job.

B. During periods of excessively hot weather (95ºF., or above), ingredients in the concrete shall be cooled insofar as possible and cold mixing water shall be used to maintain the temperature of the concrete at permissible levels all in accordance with the provisions of ACI 305. Any concrete with a temperature above 95ºF., when ready for placement will not be acceptable, and will be rejected.

C. Temperature records shall be maintained throughout the period of hot weather giving air temperature, general weather conditions (calm, windy, clear, cloudy, etc.) and relative humidity. Records shall include checks on temperature of concrete as delivered and after placing in forms. Data should be correlated with the progress of the work so that conditions surrounding the construction of any part of the structure can be ascertained.

3.13 SEALING OF JOINTS

A. Where indicated on the Drawings, expansion joints and control joints shall be sealed with joint sealant in accordance with the precautions specified in the Appendix of ASTM C 962, and as specified in Section 07 92 00, JOINT SEALANTS.

3.14 FIELD QUALITY CONTROL

A. Testing Services: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:

1. Testing Frequency: Obtain at least 1 composite sample for each 5000 sq. ft. or fraction thereof of each concrete mix placed each day.

2. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.

3. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mix. Perform additional tests when concrete consistency appears to change.
4. Air Content: ASTM C 231, pressure method; one test for each composite sample, but not less than one test for each day's pour of each concrete mix.
5. Concrete Temperature: ASTM C 1064; one test hourly when air temperature is 40 deg F (4.4 deg C) and below and when 80 deg F (27 deg C) and above, and one test for each composite sample.
6. Compression Test Specimens: ASTM C 31/C 31M; cast and laboratory cure one set of three standard cylinder specimens for each composite sample.
7. Compressive-Strength Tests: ASTM C 39/C 39M; test 1 specimen at 7 days and 2 specimens at 28 days.
    a. A compressive-strength test shall be the average compressive strength from 2 specimens obtained from same composite sample and tested at 28 days.

B. Strength of each concrete mix will be satisfactory if average of any 3 consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi (3.4 MPa).

C. Test results shall be reported in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.

D. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but will not be used as sole basis for approval or rejection of concrete.

E. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Architect.

F. Remove and replace concrete pavement where test results indicate that it does not comply with specified requirements.

G. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

3.15 PROTECTION OF CONCRETE SURFACES

A. Concrete surfaces shall be protected from traffic or damage until surfaces have hardened sufficiently. If necessary 1/2 in. thick plywood sheets shall be used to protect the exposed surface.

B. Drill test cores, where directed by Architect, when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory

pavement areas with portland cement concrete bonded to pavement with epoxy adhesive.

3.16 CONSTRUCTION WASTE MANAGEMENT

A. Comply with the requirements of Division 01, GENERAL REQUIREMENTS, for removal and disposal of construction debris and waste.

1. Do not allow excavated materials to accumulate on-site.

END OF SECTION

SECTION 32 13 13
CONCRETE PAVING

PART 1-GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.2 DESCRIPTION OF WORK

A. Work Included: Provide labor, materials, and equipment necessary to complete the work of this Section, including but not limited to the following:

1. Cement concrete paving, including walkways, ramps and accessible curb cuts.
2. Concrete base for unit pavers.
3. Pavement-marking paint.

B. Alternates: Not Applicable.

C. Items to Be Installed Only: Not Applicable.

D. Items to Be Furnished Only: Not Applicable.

E. Related Work: The following items are not included in this Section and will be performed under the designated Sections:

1. Section 033000 - CAST-IN-PLACE CONCRETE for general building applications of concrete.
2. Section 312000 - EARTH MOVING for subgrade preparation, grading, and subbase course.

1.3 SUBMITTALS

Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

A. Product Data: For each type of product indicated. Include technical data and tested physical and performance properties.

B. Design Mixtures: For each concrete pavement mixture. Include alternate mixture designs when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

C. Qualification Data: For manufacturer and testing agency.

D. Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated, based on comprehensive testing of current materials:

1. Aggregates. Include service record data indicating absence of deleterious expansion of concrete due to alkali-aggregate reactivity.

E. Material Certificates: Signed by manufacturers certifying that each of the following materials complies with requirements:

1. Cementitious materials.
2. Steel reinforcement and reinforcement accessories.
3. Fiber reinforcement.
4. Admixtures.
5. Curing compounds.
6. Applied finish materials.
7. Joint fillers.

F. Field quality-control test reports.

1.4 QUALITY ASSURANCE

A. Manufacturer Qualifications: Manufacturer of ready-mixed concrete products who complies with ASTM C 94/C 94M requirements for production facilities and equipment.

1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities."

B. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of the local authorities having jurisdiction for concrete asphalt paving work.

1. Comply with requirements of the Americans with Disabilities Act (ADA) and the Massachusetts Architectural Access Board (MAAB). If these requirements cannot be met with the grades and slopes indicated on the plans, notify the Designer immediately.
2. Comply with requirements of the local authorities having jurisdiction concerning the location and construction of accessible curb cuts.

C. ACI Publications: Comply with ACI 301, "Specification for Structural Concrete" and ACI 360, “Design of Slabs-on-Ground,” unless modified by requirements in the Contract Documents.

D. Mockups: Cast mockups of full-size sections of concrete pavement to demonstrate typical joints, surface finish, texture, color, and standard of workmanship.

1. Build mockups in the location and of the size indicated or, if not indicated, as directed by Designer.
2. Notify Designer seven days in advance of dates and times when mockups will be constructed.
3. Obtain Designer's approval of mockups before starting construction.
4. Maintain approved mockups during construction in an undisturbed condition as a standard for judging the completed pavement.
5. Demolish and remove approved mockups from the site when directed by Designer.
6. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

E. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 01.

1. Before submitting design mixtures, review concrete pavement mixture design and examine procedures for ensuring quality of concrete materials and concrete pavement construction practices. Require representatives, including the following, of each entity directly concerned with concrete pavement, to attend conference:

a. Contractor's superintendent.
b. Independent testing agency responsible for concrete design mixtures.
c. Ready-mix concrete producer.
d. Concrete pavement subcontractor.
e. Owner’s Representative.

1.5 ADA AND MAAB COMPLIANCE

A. Comply with American with Disabilities Act (ADA) and the requirements of the Massachusetts Architectural Access Board (MAAB).
1. Slopes: Walkways as defined by Section 22.1 of 521 CMR, shall be graded to a maximum of 4.5%. The cross-pitch (perpendicular to travel) for walkways and paths shall be constructed at 1.5%. The slopes of ramps and side slopes on handicap curb cuts as defined by Section 21.1 of 521 CMR shall be constructed at 7% maximum. Ramps as defined in Section 24.1 of 521 CMR, shall be constructed to a maximum slope of 7%.
2. The Contractor is to assume that sidewalk grades will be verified and checked with a 2-foot long electronic ‘smart level’.
3. A 5’-0” minimum level area of 1.5% pitch shall be provided at entrances to buildings. Puddling or ponding of water at the entrances will not be accepted.
4. Handicap parking spaces and access aisles shall be graded level with the slope not to exceed 1.8% in any direction.
5. The requirements specified hereinabove shall supercede the grades indicated on the Drawings. If these requirements cannot be met with the grades indicated on the Drawings, the Designer shall be notified immediately for direction.

1.6 PROJECT CONDITIONS

A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

B. Environmental Limitations: Do not apply concrete materials if subgrade is wet or excessively damp, or if rain is imminent or expected before time required for adequate cure.

C. Pavement-Marking Paint: Proceed with pavement marking only on clean, dry surfaces, at a minimum ambient or surface temperature of 55 deg F for water-based materials, and not exceeding 95 deg F.

PART 2-PRODUCTS

2.1 FORMS

A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, smooth exposed surfaces.
1. Use flexible or curved forms for curves with a radius 100 feet or less.

B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces and contains no PCBs or other restricted chemicals.

2.2 STEEL REINFORCEMENT

A. Plain-Steel Welded Wire Reinforcement: ASTM A 185, fabricated from as-drawn steel wire into flat sheets.

B. Deformed-Steel Welded Wire Reinforcement: ASTM A 497, flat sheet.

C. Reinforcing Bars: ASTM A 615/A 615M, Grade 60; deformed.

D. Galvanized Reinforcing Bars: ASTM A 767/A 767M, Class II zinc coated, hot-dip galvanized after fabrication and bending; with ASTM A 615/A 615M, Grade 60 deformed bars.

E. Steel Bar Mats: ASTM A 184/A 184M; with ASTM A 615/A 615M, Grade 60, deformed bars; assembled with clips.

F. Plain Steel Wire: ASTM A 82, as drawn.

G. Deformed-Steel Wire: ASTM A 496.

H. Joint Dowel Bars: Plain steel bars, ASTM A 615/A 615M, Grade 60. Cut bars true to length with ends square and free of burrs.

I. Tie Bars: ASTM A 615/A 615M, Grade 60, deformed.

J. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded wire reinforcement, and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice."

K. Zinc Repair Material: ASTM A 780.

2.3 CONCRETE MATERIALS

A. Cementitious Material: Use one of the following cementitious materials, of the same type, brand, and source throughout the Project:

1. Portland Cement: ASTM C 150, Type I or II. Supplement with the following:
   a. Fly Ash: ASTM C 618, Class C or F.
   b. Ground Granulated Blast-Furnace Slag: ASTM C 989, Grade 100 or 120.

B. Normal-Weight Aggregates: ASTM C 33, Class 4S coarse aggregate, uniformly graded. Provide aggregates from a single source.

C. Water: ASTM C 94/C 94M.

D. Air-Entraining Admixture: ASTM C 260.

E. Chemical Admixtures: ASTM C 494/C 494M, of type suitable for application, certified by manufacturer to be compatible with other admixtures and to contain not more than 0.1 percent water-soluble chloride ions by mass of cementitious material.

2.4 FIBER REINFORCEMENT

A. Synthetic Fiber: Monofilament or fibrillated polypropylene fibers engineered and designed for use in concrete pavement, complying with ASTM C 1116, Type III.

2.5 CURING MATERIALS

A. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth.

B. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.

C. Water: Potable.

D. Evaporation Retarder: Waterborne, monomolecular film forming; manufactured for application to fresh concrete.

E. Clear Waterborne Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B, dissipating.

F. White Waterborne Membrane-Forming Curing Compound: ASTM C 309, Type 2, Class B.

G. A Silane/Siloxane based penetrating sealer shall be applied per the manufacturer's instructions.

2.6 AUXILIARY MATERIALS

A. Expansion- and Isolation-Joint-Filler Strips: ASTM D 1752, cork or self-expanding cork.

B. Slip-Resistive Aggregate Finish: Factory-graded, packaged, rustproof, nonglazing, abrasive aggregate of fused aluminum-oxide granules or crushed emery with emery aggregate containing not less than 50 percent aluminum oxide and not less than 20 percent ferric oxide; unaffected by freezing, moisture, and cleaning materials.

C. Pavement-Marking Paint: Acrylic/latex type, low VOC, waterborne emulsion, lead, and chromate free, ready mixed, complying with FS TT-P-1952, with drying time of less than 45 minutes.

1. Color: As indicated.

D. Detectable Warning Panels shall have dome geometry in accordance with ADA Regulations for Detectable Warning on Curb Ramps. They shall be raised truncated domes with a nominal diameter of 0.9-inches, a nominal height of 0.2-inches, and a center-to-center spacing of 1.6 inches to 2.4-inches. Panels shall be 24-inches deep in the direction of travel and the full width of the proposed ramp. The panel shall be a homogeneous glass and carbon reinforced composite, which is colorfast, and UV stable. The panel is to be colored throughout and not a painted coating. The color is to be contrasting to the background sidewalk color. The panels shall have a compressive strength in excess of 10,000 psi, flexural strength in excess of 3,000 psi and a slip resistance in excess of 0.8 wet or dry.

E. Wheel Stops: Precast, air-entrained concrete, 2500-psi minimum compressive strength, 4-1/2 inches high by 9 inches wide by 72 inches long. Provide chamfered corners, drainage slots on underside, and holes for anchoring to substrate.

1. Dowels: Galvanized steel, 3/4-inch diameter, 10-inch minimum length.

2.7 CONCRETE MIXTURES

A. Prepare design mixtures, proportioned according to ACI 301, with the following properties:

1. Compressive Strength (28 Days): 4,500 psi.

2. Maximum Water-Cementitious Materials Ratio at Point of Placement: 0.40.
3. Air Content: 6 percent plus or minus 1.5 percent for 3/4-inch nominal maximum aggregate size.

B. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.

C. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement according to ACI 301 requirements as follows:
1. Fly Ash or Pozzolan: 25 percent.
2. Ground Granulated Blast-Furnace Slag: 50 percent.
3. Combined Fly Ash or Pozzolan, and Ground Granulated Blast-Furnace Slag: 50 percent, with fly ash or pozzolan not exceeding 25 percent.

D. Synthetic Fiber: Uniformly disperse in concrete mix at manufacturer's recommended rate, but not less than 1.0 lb./cu. yd.

2.8 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M and ASTM C 1116. Furnish batch certificates for each batch discharged and used in the Work.
1. When air temperature is between 85 deg F and 90 deg F, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F, reduce mixing and delivery time to 60 minutes.

B. Project-Site Mixing: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M. Mix concrete materials in appropriate drum-type batch machine mixer.
1. For concrete mixes of 1 cu. yd. or smaller, continue mixing at least 1-1/2 minutes, but not more than 5 minutes after ingredients are in mixer, before any part of batch is released.
2. For concrete mixes larger than 1 cu. yd., increase mixing time by 15 seconds for each additional 1 cu. yd.
3. Provide batch ticket for each batch discharged and used in the Work, indicating Project identification name and number, date, mixture type, mixing time, quantity, and amount of water added.

PART 3-EXECUTION

3.1 EXAMINATION

A. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.

B. Proof-roll subgrade below pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

C. Proceed with paving only after unsatisfactory conditions have been corrected.

3.2 EDGE FORMS AND SCREED CONSTRUCTION

A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides for pavement to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.

B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

3.3 STEEL REINFORCEMENT

A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.

3.4 JOINTS

A. General: Form construction, expansion (isolation), and control (contraction) joints and tool edgings true to line with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline, unless otherwise indicated. Joints produced using a conventional wet cut saw shall be made within 4 hours in hot weather to 12 hours in cold weather after the slab has been finished in an area, Joints produced using early-entry dry-cut saws shall be made within 1 hour in hot weather to 4 hours in cold weather after completing the finishing of the slab in that joint location.

B. Construction Joints: Set construction joints at side and end terminations of pavement and at locations where pavement operations are stopped for more than one-half hour unless pavement terminates at expansion joints.

C. Expansion (Isolation) Joints: Form expansion joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, walks, buildings, frost pads, other fixed objects, and where indicated.

D. Control (Contraction) Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct control joints for a depth equal to at least one-fourth of the concrete thickness or 1 inch whichever is greater,

3.5 CONCRETE PLACEMENT

A. Inspection: Before placing concrete, inspect and complete formwork installation, steel reinforcement, and items to be embedded or cast in. Notify other trades to permit installation of their work.

B. Moisten subbase to provide a uniform dampened condition at time concrete is placed.

C. Comply with ACI 301 requirements for measuring, mixing, transporting, and placing concrete.

D. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.

E. Screed pavement surfaces with a straight edge and strike off.

F. Commence initial floating using bull floats or darbies to impart an open textured and uniform surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.

G. Cold-Weather Placement: Comply with ACI 306.1 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.

1. When air temperature has fallen to or is expected to fall below 40 deg F, uniformly heat water and aggregates before mixing, to obtain a concrete mixture temperature of not less than 50 deg F and not more than 80 deg F at point of placement.

2. Do not use frozen materials or materials containing ice or snow.
3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in mix designs.

3.6 FLOAT FINISHING

A. General: Do not add water to concrete surfaces during finishing operations.

B. Float Finish: Begin the second floating operation when bleed-water sheen has disappeared and concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats, or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots and fill low spots. Refloat surface immediately to uniform granular texture.

1. Medium-to-Coarse-Textured Broom Finish: Provide a coarse finish by striating float-finished concrete surface 1/16 to 1/8-inch-deep with a stiff-bristled broom, perpendicular to line of traffic.

C. Slip-Resistive Aggregate Finish: Before final floating, spread slip-resistive aggregate finish on pavement surface according to manufacturer's written instructions.

1. Cure concrete with curing compound recommended by slip-resistive aggregate manufacturer. Apply curing compound immediately after final finishing.
2. After curing, lightly work surface with a steel wire brush or abrasive stone and water to expose nonslip aggregate.

3.7 CONCRETE PROTECTION AND CURING

A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.

B. Comply with ACI 306.1 for cold-weather protection.

C. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb./sq. ft. x h before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.

D. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.

E. Curing Methods: Cure concrete by moisture-retaining-cover curing or curing compound, as follows:

1. Moisture-Retaining-Cover Curing: Cover concrete surfaces with moisture-retaining cover for curing concrete, placed in widest practicable width, with sides and ends lapped at least 12 inches, and sealed by waterproof tape or adhesive. Immediately repair any holes or tears during curing period using cover material and waterproof tape.
2. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating and repair damage during curing period.

3.8 PAVEMENT TOLERANCES

A. Accessibility: Comply with requirements of Massachusetts Architectural Access Board and ADAAG requirements. Remove and replace paving that does not meet required tolerances when measured with a 2-foot straight edge.

B. Comply with tolerances of ACI 117 and as follows:

1. Elevation: 1/4 inch.
2. Thickness: Plus 3/8 inch, minus 1/4 inch.
3. Surface: Gap below 10-foot- long, unleveled straightedge not to exceed 1/4 inch.
4. Joint Spacing: 3 inches.
5. Contraction Joint Depth: Plus 1/4 inch, no minus.
6. Joint Width: Plus 1/8 inch, no minus.

3.9 PAVEMENT MARKING

A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Designer.

B. Allow concrete pavement to cure for 28 days and be dry before starting pavement marking.

C. Sweep and clean surface to eliminate loose material and dust.

D. Apply paint with mechanical equipment to produce pavement markings of dimensions indicated with uniform, straight edges. Apply at manufacturer's recommended rates to provide a minimum wet film thickness of 15 mils.

3.10 WHEEL STOPS – NOT USED

3.11 FIELD QUALITY CONTROL

A. Independent Testing Agency: Cooperate with the Independent Testing Agency engaged by Owner for field quality control activities for the Work of this Section. Refer also to Section 014325 - TESTING AGENCY SERVICES.

B. Testing Services: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:

1. Testing Frequency: Obtain at least 1 composite sample for each 100 cu. yd. or fraction thereof of each concrete mix placed each day.
   a. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
2. Air Content: ASTM C 231, pressure method; one test for each composite sample, but not less than one test for each day's pour of each concrete mix.
3. Concrete Temperature: ASTM C 1064; one test hourly when air temperature is 40 deg F and below and when 80 deg F and above, and one test for each composite sample.
4. Compression Test Specimens: ASTM C 31/C 31M; cast and laboratory cure one set of three standard cylinder specimens for each composite sample.
5. Compressive-Strength Tests: ASTM C 39/C 39M; test 1 specimen at 7 days and 2 specimens at 28 days.

a. A compressive-strength test shall be the average compressive strength from 2 specimens obtained from same composite sample and tested at 28 days.

C. Strength of each concrete mix will be satisfactory if average of any 3 consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi.

D. Test results shall be reported in writing to Designer, Owner's Representative, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.

E. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Designer but will not be used as sole basis for approval or rejection of concrete.

F. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Designer.

G. Remove and replace concrete pavement where test results indicate that it does not comply with specified requirements.

H. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

3.12 REPAIRS AND PROTECTION

A. Remove and replace concrete pavement that is broken, damaged, or defective or that does not comply with requirements in this Section.

B. Drill test cores, where directed by Designer, when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory pavement areas with portland cement concrete bonded to pavement with epoxy adhesive.

C. Protect concrete from damage. Exclude traffic from pavement for at least 14 days after placement. When construction traffic is permitted, maintain pavement as clean as possible by removing surface stains and spillage of materials as they occur.

D. Maintain concrete pavement free of stains, discoloration, dirt, and other foreign material. Sweep concrete pavement not more than two days before date scheduled for Substantial Completion inspections.

End of Section

Section321413.13
CONCRETE UNIT PAVING

PART 1 GENERAL

1.0 RELATED DOCUMENTS

A. Division 00 – PROCUREMENT AND CONTRACTING REQUIREMENTS
Division 01 - GENERAL REQUIREMENTS, as listed in the Table of Contents, including but not limited to the following sections, shall be included in and made a part of this Section:
01 30 00 – SUBMITTALS
01 43 39 – MOCK-UPS
01 81 13 – SUSTAINABLE DESIGN REQUIREMENTS

1.1 DESCRIPTION OF WORK

A. The work includes furnishing all labor, materials, equipment, and supervision to construct the concrete unit paving, in accordance with the Drawings and Specifications.

1. Concrete unit pavers installed on a sand setting bed over a concrete base.

1.2 RELATED WORK

A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that directly relate to work of this Section include, but are not limited to:

1. Section 014320, QUALITY CONTROL AND TESTING SERVICES; Inspection and testing.
2. Section 033001, CAST-IN-PLACE CONCRETE – SITEWORK; Reinforced concrete base with vertical weep holes for unit pavers.
3. Section 07 92 01, EXTERIOR JOINT SEALANTS.

1.3 REFERENCES

A. Comply with applicable requirements of the following standards. Where these standards conflict with other specified requirements, the most restrictive requirement shall govern.

1. American Association of State Highway and Transportation Officials (AASHTO):

Specifications	Standard Specifications for Highway Bridges
M 43	Standard Size of Coarse Aggregate for Highway Construction

2. American Society for Testing and Materials (ASTM):

C 67	Sampling and Testing Brick and Structural Clay

	Tile
C 91	Masonry Cement
C 136	Sieve Analysis of Fine and Coarse Aggregates
C 144	Aggregate for Masonry Mortar
C 216	Facing Brick (Solid Masonry Units Made from Clay or Shale)
C 902	Pedestrian and Light Traffic Paving Brick
D 36	Softening Point of Bitumen (Ring-and-Ball Apparatus)
D 113	Ductility of Bituminous Materials
D 3381 in	Viscosity-Graded Asphalt Cement for Use Pavement Construction.

3. Americans with Disabilities Act (ADA):

Appendix to Part 1191	Accessibility Guidelines for Buildings and Facilities

4. National Concrete Masonry Association (NCMA):

A-10	Solid Concrete Masonry Paving Units

5. State of New Hampshire Department of Transportation (NHDOT):

Specifications Bridge	Standard Specifications for Road and Construction

1.4 SUBMITTALS

A. Submit manufacturer's product data for each type of concrete paver.

B. Submit a minimum of three concrete pavers of each type and size required to Architect for approval. Samples shall exhibit the full color range of pavers to be provided.

C. Submit sand setting bed information to Architect for approval.

D. Submit polymeric joint sand information and sample for Architect approval.

E. Submit a sample of edge material, 12 in. length, with one bolt.

F. Test Report:

1. Test report of precast concrete paver shall be submitted.
2. Testing shall be done by an independent testing laboratory. Test procedures

shall conform to ASTM C 936 methods, where applicable.

3. Test report shall indicate, as a minimum, the following:
   a. Compressive strength, psi.
   b. Absorption, 5 hr. submersion in cold water.
   c. Absorption, 24 hr. submersion in cold Water.
   d. Maximum saturation coefficient.
   e. Initial rate of absorption (suction).
   f. Abrasion index.
   g. Freeze-thaw.

1.5 IN-SITU MOCK-UP

A. Construct the initial 6' x 6' panel of concrete unit paving in a location selected with the architect consistent with dimensions and details for concrete unit paving as shown on the Drawings. This panel will serve as the project mockup for approval and, if approved, may remain as part of the final project. This in-situ mockup panel shall exhibit paving pattern, finish, color, direction, and required jointing and relationship to adjacent paving.
Sample panel shall be inspected by the Architect prior to any additional unit paving construction. If the original panel is not acceptable, remove and construct additional panels at no cost to the Owner until an acceptable panel is constructed. The acceptable panel shall become the standard for the entire job, and may be included as part of the final installation.

1. Schedule preconstruction meeting with Architect before construction mockup.
2. Notify Architect seven days in advance of dates and times when mockups will be constructed.
3. Demonstrate the proposed range of aesthetic effects and workmanship.
4. Obtain Architect's approval of mockups before starting paver installation.
5. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
6. Demolish and remove rejected panels when directed.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Pavers shall be carefully packed and loaded for shipment and all necessary precautions taken against damage in transit and handling.

B. Aggregate materials shall be kept dry and free from soiling.

C. Pavers damaged in any manner will be rejected and replaced with new materials at no additional cost to the Owner.

PART 2 PRODUCTS

2.1 CONCRETE PAVERS – Note: Drawing detail is shown for paver thickness of 3", if 4" thick pavers are preferred by Owner setting detail will be modified.

A. Pavers will come in (4) sizes based on the design patterns as shown in the drawings. Paver sizes may vary depending on manufacturer but should most closely align with the following:
   a. P1: Pavers shall be 4 in. x 8 in. x 3 in thickness., gauged.

b. P2: Paver shall be 6 in x 12 in x 3 in thickness, gauged.
c. P3: Pavers shall be 8 in x 8 in x 3 in thickness, gauged.
d. P4: Pavers shall be 12 in x 12 in x 3 in thickness, gauged.

B. Approved paver manufacturers and colors are:

1. Hanover Prest Concrete Pavers, hydraulically precast concrete pavers, manufactured by Hanover Architectural Products, Inc., Hanover, PA 17331, www.hanoverpavers.com or approved equal. Pavers shall be as follows:

a. Color: TBD Based on submittals but similar to: mixed (2) Matrix colors (M1983 and M1810) and (1) Standard color Cream. Submit samples for approval. Architect may require additional sample colors for final determination.
b. Finish: Tudor Finish, all pavers.

2. Tectura Designs Expressions pavers by Wausau Tile Inc, PO Box 1520, Wausau, WI 54402-1520, p: 800.388.8729, www.tecturadesigns.com :

a. Color: TBD based on submittals but similar to:
35% HXP-110/ 35 % HXP-50/ 30% HXP-10
b. Finish: Standard

3. Narrow Modular pavers by Stepstone Inc, 17025 So. Main Street, Gardena, CA p: 310.327.7474, www.stepstoneinc.com

a. Color: TBD based on submittals but similar to:
35% Porcelain 1813/ 35 % French Gray 1804/ 30% Agave 1812
b. Finish: Light sand blast

B. Pavers shall be solid concrete unit pavers in sizes and textures indicated. Produced from a single homogenous mix (no lamination) containing laminin and possessing the following physical characteristics:

1. No efflorescence after 7 days exposure to water ASTM C-67
2. UV Resistant ASTM G 154
3. Absorption less than 4% ASTM C 936
4. Average compressive strength 8,000 psi ASTM C 936
5. Average absorption less than 5% ASTM C 936
6. Average Abrasion coefficient .0937 ASTM C 418
7. Static coefficient of friction Dry 1.08 Wet .85 ASTM C 1028
8. Stain resistant ASTM C 1378

2.2 SETTING BED SAND

A. Setting bed Sand shall be a clean, washed, uniformly well graded masonry sand with 100 percent passing No. 16 (1.18-mm) sieve and no more than 10 percent passing No. 200 (0.075- mm) sieve, conforming to ASTM C 144, except that the fineness modulus shall be 2.25+ 0.10. Sand shall be from a single source. Source of supply shall not be changed during course of job without written permission of the Architect.

2.3 JOINT FILLER - POLYMERIC SAND

A. Sand shall be a polymeric sand specially formulated for the filling of paver or slab joints on horizontal surfaces exposed to normal traffic (driveways, patios, sidewalks, etc.). Maximum width of 1.5 cm (0.5 in.). Minimum depth of 3 cm (1.25 in.). Sand shall be one of the following or as required by paver manufacturer:

1. Hanover Polymeric Sand for Paving Joints, RG Polymeric Sand by Hanover Architectural Products Inc., Hanover, PA 17331
2. HP NextGel Jointing Sand by Techniseal, Quebec, 300 Liberte Avenue, Candiac, Canada, 800-465-7325, techniseal.com
3. Polymeric Plus (RG+) Polymeric Sand by Unilock, Uxbridge, MA unilock.com.

B. Color will be selected by Architect.

2.5 PAVER RESTRAINT

A. Approved Products and manufacturers:

a. Permaloc AsphaltEdge, with 0.210 inch (5.33 mm) thick exposed top lip x 2.5" (63.5mm) high x 8 feet (2.44 meters) long, extruded aluminum, alloy 6005, T-5 hardness as manufactured by Permaloc Corporation, Holland MI 49424, telephone (800) 356-9660 or (616) 399-9600, or approved equal. Horizontal base to have upward facing angle profile designed to integrate restraint. Section shall have holes in base spaced 4 inches (102 mm) apart along its length to receive anchors.
b. Duralum aluminum paver restraint edging by JD Russell Company, PO Box 183471, Shelby Township, MI 48318 p: 586.254.8500; www.jdrussell.com;
c. Iron Edge by Border Concepts, 7621 Little Ave, Suite 426, Charlotte, NC 28226, p: 800.845.3343, www.borderconcepts.com.

B. Connection Method: Varies per manufacturer. General: Section ends shall splice together with horizontal 0.060 inch (1.52 mm) thick x 1 inch (25 mm) wide, or 0.530 inch (13.5 mm) wide for 1 inch (25 mm) high edging x 4 inches (102 mm) long aluminum sliding connector.

C. Anchors: 3/16 inch x 1-1/2 inches (4.8 mm x 38 mm) or longer Ardox concrete nail, or drive pin fastener equal to Hilti DX 40 powder actuated pin or Ramset Trakfast Automatic Fastening System pin.

D. Finish: Black. Paint finish shall comply with AAMA 2603 for electrostatically baked on paint.

2.6 WATER

A. Water shall be potable and shall be free of injurious contaminants.

2.7 GEOTEXTILE BARRIER FOR SAND SETTING BED

A. Provide Geotextile material conforming to the following performance characteristics, measured per the test methods referenced:
1. 4 oz., nonwoven needle punched geotextile composed of 100% polypropylene staple fibers that are inert to biological degradation and resists naturally encountered chemicals, alkalis, and acids.
2. Grab Tensile Strength: ASTM D 4632: 115 lbs.

3. Grab Tensile Elongation: ASTM D 4632: 50%
4. Trapezoidal Tear: ASTM D4533: 50 lbs.
5. Puncture: ASTM D4833: 65 lbs.
6. Apparent Opening Size: ASTM D 4751: 0.212 mm, 70 U.S. Sieve
7. Permittivity: ASTM D 4491: 2.0 sec -1
8. Flow Rate: ASTM D 4491: 140 gal/min/s.f.

B. Provide Mirafi 140N as available from Tencate Geosynthetics Americas, 365 South Holland Drive, Pendergrass, Georgia 30567, 706-693-2226, spec@tencategeo.com, tencategeo.com, or approved equal.

PART 3 EXECUTION

3.1 ACCEPTABILITY OF BASE

A. Contractor shall examine the concrete base slab to determine its adequacy to receive concrete pavers and sand setting bed. Evidence of inadequate base shall be brought to the immediate attention of the Architect.

B. Start of work of this Section shall constitute acceptance of concrete base slab.

3.2 PREPARATION

A. Vacuum clean concrete substrates to remove dirt, dust, debris, and loose particles.

3.3 PAVER RESTRAINT

A. Locate border line of edging with string or other means to assure border straightness and curves as designed.

B. Edging Installation: Install base of edging resting on base and folding underneath paver:

1. Drive powder actuated nails through edge base to concrete.
2. Anchor each section end with anchor.
3. Concrete Base: Hilti DX A41 Fully Automatic Powder Actuated Tool is desirable where sufficient hold can be obtained. Provide 3/4 inches (19 mm) to 1 inches (25 mm) nail at 4 inches (102 mm) to 12 inches (305 mm) on center spacing with applicable charge recommended. Anchor into outer 1 inch (25 mm) of base of restraint edging and not less than 2.5 inches (63.5 mm) from edge of concrete.
4. Securely connect sections in accordance with manufacturer's instructions. Provide additional anchors at closer spacing as necessary to firmly secure edging for permanent intended use.

3.4 INSTALLATION, GENERAL

A. Do not use unit pavers with chips, cracks, voids, discolorations, and other defects that might be visible or cause staining in finished work.

B. Mix pavers from several pallets or cubes, as they are placed, to produce uniform blend of colors and textures.

C. Cut unit pavers with motor-driven masonry saw equipment to provide clean, sharp, unchipped edges. Cut units to provide pattern indicated and to fit adjoining work neatly. Use full units without cutting where possible. Hammer cutting is not acceptable.

D. Joint Pattern: As indicated on the Drawings. No joints to align between rows unless otherwise noted. If pavers need to be cut to maintain a staggered bond cut back at least 3 pavers to provide gradual shift in joint alignment.

E. Tolerances: Do not exceed 1/16-inch (1.6-mm) unit-to-unit offset from flush (lippage) nor 1/8 inch in 24 inches (3 mm in 600 mm) and 1/4 inch in 10 feet (6 mm in 3 m) from level, or indicated slope, for finished surface of paving.

F. Expansion and Control Joints: Provide for sealant-filled joints at locations and of widths indicated. Provide joint filler as backing for sealant-filled joints where indicated. Install joint filler before setting pavers. Sealant materials and installation are specified in Section 07 92 01, EXTERIOR JOINT SEALANTS.

G. Minimum Paver Dimensions:

1. Minimum dimensions for trimmed pavers are 3” in width and 4” in length. Avoid ‘wedges’ or small pieces of pavers. If required to meet minimum dimensions trim 3-4 course of adjacent pavers evenly. Any installed pavers not meeting minimum dimensions are to be removed and replaced.
2. Whenever possible use whole courses of pavers and align joint pattern with other site elements to achieve consistent jointing and minimize trimming.
3. Review paver layout and jointing patterns with architect in field prior to installation.

3.5 SETTING CONCRETE PAVERS – SAND BED OVER CONCRETE

A. Core 2” diameter weep holes in concrete base at 3’ on center per detail completely through concrete to provide drainage to material below.

B. Fill weep holes with #8 washed stone

C Install geotextile fabric over concrete and drainage holes.

D. Place sand setting bed 1” thick and compact to accept pavers and avoid settling.

E. Concrete pavers shall be neatly cut and fitted at all perimeters and closures to fit neatly and closely, with joints uniform in thickness. Pavers shall be cut with a water-cooled, cut-off wheel masonry saw using a diamond blade. Concrete pavers with chips, cracks, stains, or other defects which might be visible in the finished work shall not be used.

F. Wet concrete pavers before laying if the initial rate of absorption exceeds 30 g/30 sq. in. (30 g/194 sq. cm) per minute when tested per ASTM C 67. Allow units to absorb water so they are damp but not wet at the time of laying.

G. Tamp or beat pavers with a wooden block or rubber mallet to obtain full contact with setting bed and to bring finished surfaces within indicated tolerances. Set each paver in a single operation before initial set of mortar; do not return to areas already set and disturb pavers for purposes of realigning finished surfaces or adjusting joints.

H. Spaced Joint Widths: Provide hand tight joints.

3.5 JOINT TREATMENT - SAND

A. On a dry day, after pavers have been installed, joints of pavers shall be filled by sweeping dry sand into them. When joints are filled, paver surfaces shall be lightly misted with a fine spray of water to settle sand joint filler. Additional dry sand shall be added and swept into joints, repeating the process until joints are completely filled. Pavers shall then be swept clean and rinsed with a fine spray, careful not to dislodge joint filler.

3.6 CLEANING OF PAVED SURFACE

A. After completion of the concrete pavers, paved areas shall be thoroughly swept clean and surface shall be left unsoiled. Where required, surface shall be cleaned with water or an approved cleaner.

END OF SECTION

SECTION 32 14 43

PERMEABLE UNIT PAVING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Division 00 – PROCUREMENT AND CONTRACTING REQUIREMENTS and applicable parts of Division 01 - GENERAL REQUIREMENTS, as listed in the Table of Contents, shall be included in and made a part of this Section.

1.2 DESCRIPTION OF WORK

A. Provide all equipment and materials, and do all work necessary to furnish and install permeable concrete unit paving as indicated on the Drawings and as specified herein.

1.3 RELATED WORK

A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that relate directly to work of this Section include, but are not limited to the following:
1. Section 321313, CONCRETE PAVING.
2. Section 312300, EARTH MOVING.

1.4 REFERENCES

A. Comply with applicable requirements of the following standards. Where these standards conflict with other specified requirements, the most restrictive requirement shall govern.
1. American Society of Testing Materials (ASTM):

ASTM C67	Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units
ASTM C13	Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	Method for Sieve Analysis for Fine and Coarse Aggregate
ASTM C140	Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units
ASTM D448	Standard Classification for Sizes of Aggregate for Road and Bridge Construction
ASTM C936	Standard Specification for Solid Interlocking Concrete Pavers
ASTM C979	Specification for Pigments for Integrally Colored Concrete
ASTM C1781	Standard Test Method for Surface Infiltration Rate of Permeable Unit Pavement Systems
ASTM E2835	Standard Test Method for Measuring Deflections using a Portable Impulse Plate Load Test Device

2. Interlocking Concrete Pavement Institute (ICPI):
   Permeable Interlocking Concrete Pavement manual.
3. Commonwealth of Massachusetts Highway Department (MHD):
   Specifications Standard Specifications for Highways and Bridges

1.5 SUBMITTALS

A. Submit manufacturer's product data for each type of concrete paver.

B. Submit a minimum of three permeable unit pavers of each type and size required to Architect for approval. Samples shall exhibit the full color range of pavers to be provided.

C. Submit 8 oz. samples each of base material and joint material for unit pavers.

D. Submit product cut sheet for edge restraint indicating product manufacturer, information, dimensions, and fastening devices for approval.

E. Test Report:
1. Test report of permeable unit paver shall be submitted.
2. Testing shall be done by an independent testing laboratory. Test procedures shall conform to ASTM C 936 methods, where applicable.
3. Test report shall indicate, as a minimum, the following:
   a. Compressive strength, psi.
   b. Absorption, 5 hr. submersion in cold water.
   c. Absorption, 24 hr. submersion in cold water.
   d. Maximum saturation coefficient.
   e. Initial rate of absorption (suction).
   f. Abrasion index.
   g. Freeze-thaw.

1.6 COORDINATION

A. Work under this section shall be properly coordinated with the work of other sections to assure the steady progress of all work of the Contract.

1.7 PRODUCT DELIVERY AND STORAGE

A. Pavers shall be carefully packed and loaded for shipment and all necessary precautions taken against damage in transit and handling.

B. Aggregate materials shall be kept dry and free from soiling.

C. Pavers damaged in any manner will be rejected and replaced with new materials at no additional cost to the Owner.

PART 2 - PRODUCTS

2.1 PERMEABLE UNIT PAVERS

A. Regional Materials: Pavers shall be manufactured within 500 miles (800km) of Project site from aggregates that have been extracted, harvested, or recovered, as well as manufactured, within 500 miles (800km) of Project site.

B. Source Limitations: Obtain each type of paver from single source that has resources to provide materials and products of consistent quality in appearance and physical properties.

C. Unit Pavers for Permeable paving: Concrete paving units of shapes that provide openings between units, complying with ASTM C 902, or C1272, resistant to freezing and thawing when tested according to ASTM C 67, and made from normal weight aggregates. Colors shall be in the tan/beige range. Submit samples for approval.

1. Products: Subject to compliance with requirements, provide the following available products that may be incorporated into the Work include, but are not limited to the following:
   a. Approved Manufacturers:
      1) Unilock, Uxbridge, Massachusetts, Contact: 800-864-5625, unilock.com
      2) Hanover Permeable Pavers by Hanover Architectural Products, Inc., Hanover, PA 17331, www.hanoverpavers.com
      3) H-Series Permeable pavers by Wausau Tile Inc, PO Box 1520, Wausau, WI 54402-1520, p: 800.388.8729, www.wausautile.com

   b. Permeable/Porous Unit Paver Type:
      1) Material Standard: Comply with ASTM C 936.
      2) Color and finish: Standard colors, submit samples for approval
      3) Color Pigment Material Standard: Comply with ASTM C979.
      4) Size: rectangular units from 4” x 8” to 12” x 18” x 3 inches minimum thickness. Sizes depend on manufacturer.
      5) Joint Gap Mechanism: Hidden spacers
      6) All joint gaps to be ADA compliant
      7) Bevel Size: 1/8” rolled

2.2 BEDDING COURSE AND VOID FILLER AGGREGATE

A. The bedding course and void filler aggregate shall be washed, crusher run, free of fines, organics and soluble salts or other contaminants likely to cause efflorescence. Color of aggregate shall be in a gray to closely match the color of the pavers. The grading requirement shall comply with the following table.

1. ASTM No. 8 Grading Requirements for Bedding Course Aggregates

ASTM Sieve Size	Percent Passing (by weight)
½ in.	100
3/8 in.	85 to 100
No. 4	10 to 30
No. 8	0 to 10
No. 16	0 to 5

2.3 BASE COURSE AGGREGATES

A. The base course aggregate shall consist of open-graded stone and comply with the following standards for ASTM No. 57:

1. ASTM No. 57 Grading Requirements for Bedding Course Aggregates

ASTM Sieve Size	Percent Passing (by weight)
1½ in.	100
1 in.	95 to 100
½ in.	25 to 60
No. 4	0 to 10
No. 8	0 to 5

2.4 SUB-BASE COURSE

A. The sub-base course and void filler aggregate shall be washed, open graded stone and comply with the following

1. ASTM No. 2 Grading Requirements for Sub-Base Course Aggregates

ASTM Sieve Size	Percent Passing (by weight)
3 in.	100
2-1/2 in.	90 to 100
2 in.	35 to 70
1-1/2 in.	0 to 15
3/4 in.	0 to 5

2.5 GEOTEXTILE FABRIC

A. Provide Geotextile material conforming to the following performance characteristics, measured per the test methods referenced:

1. 4 oz., nonwoven needle punched geotextile composed of 100% polypropylene staple fibers that are inert to biological degradation and resists naturally encountered chemicals, alkalis, and acids.
2. Grab Tensile Strength: ASTM D 4632: 115 lbs.
3. Grab Tensile Elongation: ASTM D 4632: 50%
4. Trapezoidal Tear: ASTM D4533: 50 lbs.
5. Puncture: ASTM D4833: 65 lbs.
6. Apparent Opening Size: ASTM D 4751: 0.212 mm, 70 U.S. Sieve
7. Permittivity: ASTM D 4491: 2.0 sec -1
8. Flow Rate: ASTM D 4491: 140 gal/min/s.f.

B. Provide Mirafi 140N as available from Tencate Geosynthetics Americas, 365 South Holland Drive, Pendergrass, Georgia 30567, 706-693-2226, spec@tencategeo.com, tencategeo.com, or approved equal.

2.6 EDGE RESTRAINT

A. Edging shall be “StructurEdge”, aluminum edging for straight-line and curvilinear applications in corrugated L-shaped profile, manufactured by PermaLoc Corporation, Holland MI 49424, telephone (800) 356-9660; (616) 399-9600, or approved equal.

1. Edging shall be 3/16 in. thick x 2-1/4 in. height. Horizontal base shall have holes spaced 4 inches (102 mm) apart along its length to receive spikes
2. Connection Method: Section ends shall splice together with horizontal 0.060 inch (1.52 mm) thick x 1 inch (25 mm) wide x 4 inches (102 mm) long aluminum sliding connector.
3. Anchoring: 3/8 in x 10 in spiral steel spike.
4. Finish: Natural Mill Aluminum.

PART 3 - EXECUTION

3.1 INSTALLATION, GENERAL

A. Do not use unit pavers with chips, cracks, voids, discolorations, and other defects that might be visible or cause staining in finished work.

B. Mix Unit Pavers from a minimum of three (3) bundles simultaneously drawing the paver vertically rather than horizontally, as they are placed, to produce uniform blend of colors and textures.

C. Unit pavers shall completely fill the width and length of the space between the concrete paving and granite curb with complete units in numbers specified on the Drawings. Should a variance exist between site conditions and requirements of the Drawings, no work shall continue and the Landscape Architect shall be notified immediately.

D. Cut unit pavers with motor-driven masonry saw equipment to provide clean, sharp, unchipped edges. Cut units to provide pattern indicated and to fit adjoining work neatly. Use full units without cutting where possible. Hammer cutting is not acceptable.

E. Joint Pattern: As indicated on the Drawings.

F. Tolerances: Do not exceed 1/16-inch (1.6-mm) unit-to-unit offset from flush (lippage) nor 1/8 inch in 24 inches (3 mm in 600 mm) and 1/4 inch in 10 feet (6 mm in 3 m) from level, or indicated slope, for finished surface of paving.

G. Expansion and Control Joints: Provide for sealant-filled joints at locations and of widths indicated. Provide joint filler as backing for sealant-filled joints where indicated. Install joint filler before setting pavers. Sealant materials and installation are specified in Section 07 92 01, EXTERIOR JOINT SEALANTS.

3.2 SUBBRADE PREPARATION

A. The Contractor shall verify that the sub-grade has been shaped and compacted in conformance to the lines, grades and cross-sections shown on the plans.

B. If necessary, site grades can be raised using the same material as the largest base course (i.e. #2 or #57) being used for the pavers. The stone should be laid in 6” lifts and compacted using a vibratory smooth-drum roller.

C. The requirements to include sub-drains in the pavement base design would depend on the sub-grade soil conditions. Coordinate all work for any and all sub-drains with the project civil engineer. If required, the sub-drain pipe shall consist of a four inch diameter pvc perforated pipe wrapped with filter fabric. The pipe would be placed at sub-grade elevation and surrounded with a minimum of four inches of approved open-graded stone. The sub-drain shall drain into a catch basin or other frost free positive outlet.

3.3 SUB-BASE COURSE PREPARATION

A. The sub-base shall consist of a minimum thickness of twelve inches and be compacted using a vibratory smooth-drum roller. It shall be installed in lifts not to exceed six inches. Upon completion of the sub-base course installation, the area shall be proof-rolled using a heavy rubber tired

vehicle (such as a loaded tandem truck) to identify any areas requiring additional compaction. The sub-base course shall be installed to the elevation and cross section per the plan documents.

3.4 BASE COURSE

A. The base course shall consist of a thickness of four inches of aggregate placed in one lift and compacted using a vibratory smooth-drum roller until there is no visible movement of aggregate under static rolling. The base course shall be installed to the elevation and cross section per the plan documents.

3.5 BEDDING COURSE

A. The bedding course shall be spread loose in a uniform layer to give a depth after compaction of the pavers of two inches, plus or minus ½". The contractor shall screed the bedding course using either a mechanical screed beam apparatus or by the use of screed guides and boards.

B. The screeded bedding aggregate shall not be subjected to any traffic by either mechanical equipment or pedestrian use prior to the installation of the pavers. The voids left after the removal of the screed rails shall be filled with loose aggregate as the paver bedding course proceeds.

3.6 PERMEABLE UNIT PAVER INSTALLATION

A. The pavers should be installed according to the information on the cube tag. The pavers should be laid from several cubes throughout the installation.

B. Lay pavers in the pattern as shown on the drawings. Lay pavers away from the existing laying face or edge restraint in such a manner as to ensure that the pattern remains square. Chalk lines (use a heavier chalk cord) shall be used upon the bedding course to maintain straight lines. Joint spacing between pavers shall be between 1/8" and ¼"; however the joint width may need to be increased to 3/8" to maintain straight lines. Lines and grades shown on the plans shall be established and maintained during the installation of the pavers.

C. Pavers should be cut according to the instructions on the cube tag. Pavers shall be cut using a table mounted masonry wet saw.

D. Once the pavers have been placed upon the bedding course and all cut pavers have been inserted to provide the complete surface, inspect the pavers for damaged units and remove and replace those units. Once all pattern lines have been straightened, the void filler shall then be placed into the paver openings to the top of the chamfer on the pavers and the surface swept broom clean.

E. The pavement surface shall be compacted to achieve consolidation of the bedding course and pavers and brought to design levels and profiles by two passes of a suitable plate compactor. Compaction of the pavers shall be accomplished by the use of a vibratory plate compactor capable of a minimum of 4,500 pounds of compaction force. No compaction shall be permitted within three feet of unrestrained edges of the pavement. After compaction, inspect the pavers for damaged units and remove and replace those units.

F. After completing compaction, the surface tolerances shall be plus or minus ½" from finished grades. The pavers shall be flush to ½" above edge restraints. Additional void filler material shall be swept into the joints as required, to within ½" from the bottom of the chamfer on the paver.

Upon completion, the pavement surface shall be swept clean of all excess materials. Remove from the site all surplus materials, equipment and debris resulting from these operations.

G. At the locations identified for the tree grates, place a length of metal edging that extends 1 foot beyond the size of the tree grate in both directions to act as an edge restraint for the unit pavers. Secure as directed by the edge restraint manufacturer.

3.7 EDGING

A. Locate border line of edging with string or other means to assure border straightness and curves as designed.

B. Edging Installation: Install base of edging resting on compacted level base and facing away from paver.
1. Drive powder actuated nails through aluminum base.
2. Anchor each section end with anchor.
3. Securely connect sections in accordance with manufacturer's instructions. Provide additional anchors at closer spacing as necessary to firmly secure edging for permanent intended use.

3.8 FIELD QUALITY CONTROL

A. Verify final elevations for conformance to the drawings after sweeping the surface clean.
1. Prevent final Concrete Paver finished grade elevations from deviating more than 3/8" (10mm) under a 10 ft. (3 m) straightedge or indicated slope, for finished surface of paving.

B. Lippage: No greater than 1/32 in. (0.8mm) difference in height between Permeable Concrete Pavers and adjacent paved surfaces.

3.9 REPAIRING, CLEANING, AND SEALING

A. Remove and replace unit pavers that are loose, chipped, broken, stained, or otherwise damaged or that do not match adjoining units. Provide new units to match adjoining units and install in same manner as original units, with same joint treatment and with no evidence of replacement.

B. Cleaning: Remove excess dirt, debris, stains, grit, etc. from exposed paver surfaces; wash and scrub clean.
1. Clean Permeable Concrete Pavers in accordance with the manufacturer's written recommendations.

3.10 PROTECTION

A. Protect completed work from damage with ¾" thick plywood due to subsequent construction activity on the site.

3.11 PERMEABLE JOINT AGGREGATE MATERIAL REFILLING

A. Remove all debris from joint and provide additional Permeable Joint Aggregate Material after 120 days and before 150 days after date of Substantial Completion.
1. Fill Permeable Joint Aggregate material full to the lip of the paver.

3.12 CLEANING

A. Upon completion of paver installation in any area, remove all rubbish, debris, and surplus material(s) from the work area and leave in clean condition.

END OF SECTION

Section 32 15 43

STABILIZED AGGREGATE PAVING

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01, GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.2 DESCRIPTION OF WORK

A. Provide all equipment and materials, and do all work necessary to construct the aggregate (decomposed granite) paving with stabilizer material, including aggregate base and edging, as indicated on the Drawings and as specified.

1.3 RELATED SECTIONS

A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that directly relate to work of this Section include, but are not limited to:

1. Section 31 20 00, EARTH MOVING; Establishment of subgrade elevation.

1.4 REFERENCES

A. Comply with applicable requirements of the following standards. Where these standards conflict with other specified requirements, the most restrictive shall govern:

1. American Society for Testing and Materials (ASTM):

D 1557 Moisture-Density Relations of Soils and Soil Aggregate Mixtures Using 10-lb. (4.54-kg) Rammer and 18-in. (475-mm) Drop

2. Commonwealth of Massachusetts Highway Department (MHD):

Specifications Standard Specifications for Highways and Bridges

1.5 SUBMITTALS

A. Samples: The following samples shall be submitted:

Material	Sample Size or Quantity
Decomposed granite	1 lb. (3 color options for color approval)

B. Manufacturer's Product Data: Manufacturer's product data shall be submitted for the following materials:

1. Stabilizer

C. Test results for stabilized crushed stone surfacing indicating compliance with ADA Requirements for accessibility and slip resistance.

1.6 QUALITY ASSURANCE

A. Crushed granite sample of sufficient quantity shall be submitted to stabilizer manufacturer for recommended blending proportions and procedures to be followed by crushed granite supplier. Blending operations shall be performed at crushed granite supplier facility, and provided to Contractor pre-blended in accordance with stabilizer manufacturer's recommendations.

B. Installer shall provide evidence to indicate successful experience in providing crushed granite surfacing containing stabilizer binder/additive or ability to follow installation instructions.

C. Installer shall provide documentation of at least three (3) installations similar in scale (all reference projects to be equal or greater than 75% of the total square footage of the project being bid on) using specified stabilizer solution material, completed over the past five (5) years. If Contractor is not able to meet experience qualifications, Contractor shall be required to have a representative from Stabilizer Solutions be present on site for pre-construction training, installation of mockup, and at least 50% of the project installation. Contractor shall be responsible for any and all costs associated with this requirement. If contractor is unable to meet these requirements a qualified replacement contractor will be located subject to all qualifications listed above and Owner approval.

1.7 PERFORMANCE REQUIREMENTS

A. Perform gradation of decomposed granite material or 3/8" or 1/4" minus crushed aggregate in accordance with ASTM C 136 – Method for Sieve Analysis for Fine and Course.

1.8 MOCK-UP

A. General

1. Schedule mock-up for acceptance 30 days prior to constructing decomposed granite surfaces represented by the mockups.
2. Locate mock-up panels in original location or non-public areas accepted by the Architect.
3. Continue to construct mock-ups until acceptable mock-up is produced. Accepted mock-up shall be the standard for color, texture, mix ratio, and workmanship for the work.
4. Use the same decomposed granite /stabilizer mix and placement procedure, accepted in mock-ups, in the final work, unless otherwise directed by the Architect.
5. Protect accepted mock-ups from damage until completion and acceptance of the work represented by the mock-up.
6. Leave accepted mockup panel in original location or remove mock-up panels from site at completion of project, as directed by the Architect.

B. Sample panel shall be 4 ft. x 4 ft. minimum.

C. Source of Materials. Utilize the same source, stock, or brand of stabilizer material for all decomposed granite surfacing. Do not interchange materials or mixes until an additional mock-up shows that uniformity in finish texture and color, as

compared to original mock-up will be maintained. If necessary, obtain and stockpile materials in sufficient quantity to ensure continuity and uniformity.

1.9 PROJECT/SITE CONDITIONS

A. Field Measurements: Each bidder is required to visit the site of the Work to verify the existing conditions. No adjustments will be made to the Contract Sum for variations in the existing conditions.

1. Where surfacing is indicated to fit with other construction, verify dimensions of other construction by field measurements before proceeding with the work.

B. Environmental Limitations: Do not install decomposed granite or crushed 3/8” or 1/4" minus aggregate paving during rainy conditions or below 40 degrees Fahrenheit.

1.10 TESTING AND INSPECTION

A. The Owner reserves the right to test and inspect materials and construction of crushed stone surfacing in accordance with the requirements of Division 1 – General Requirements.

1.11 WARRANTY

A. Provide written warranty signed by stabilizer manufacturer, installer, and Contractor, agreeing to repair or replace all work of this section which exhibits defects in materials or workmanship. Warranty shall cover stabilizer, decomposed granite and aggregate base work. "Defects" is defined to include, but not limited to, differential settlement, ponding of water, abnormal aging or deterioration of stabilized paving system, and failure to perform as required.

1. Warranty Period: 90 days from date of Substantial Completion.
2. Contractor shall provide unconditional maintenance and repairs as required through the warranty period.

PART 2 - PRODUCTS

2.1 AGGREGATE BASE COURSE

A. Material for aggregate base course shall be a graded, granular, non-frost susceptible, free-draining material, consisting of either durable stone and coarse sand or of blast furnace slag, practically free from loam and clay, and which can be readily compacted to form a stable foundation.

1. Material shall be dense graded crushed stone conforming to MHD Specifications Section M2.01.7.

2.2 STONE DUST (DECOMPOSED GRANITE)

A. Decomposed granite or 3/8 in. or 1/4 in. crushed aggregate screenings.

1. Surfacing material shall be sand and crushed stone consisting of inert materials that are hard and durable, with stone free from surface coatings and deleterious materials. Gradation requirements shall be as follows:

2. Crushed Stone Sieve Analysis Percentage of weight Passing a Square Mesh AASHTO T11-82 and T2782.

Sieve Size	% Passing by Weight
3/8 in.	100
No. 4	90 - 100
No. 8	75 - 80
No. 16	55 - 65
No. 30	40 - 50
No. 50	25 - 35
No. 100	15 - 20
No. 200	10 - 15

B. Decomposed granite color will be selected by Architect.

2.3 STABILIZER

A. Approved product and manufacturers are:

1. Stabilizer additive shall be "Stabilizer", a non-toxic, colorless, odorless, concentrated powder organic binder capable of binding crushed aggregate screenings, manufactured by Stabilizer Solutions, Inc., 33 South 28th Street, Phoenix, AZ 85034; Tel. 602-225-5900; 1-800-336-2468; Fax: 602-225-5902; E- mail: info@stabilizersolutions.com, or approved equal.
2. Organic-lock by Envirobond Products, 2100 Bloor St. W, Suite 6191, Toronto, ON, M6S 5A5, p: (416) 628-3704, www.organic-lock.com
3. Addaset Resin Bound Permeable Paving by Chameleon Ways, PO Box 387, Center Valley, PA, www.chameleonways.com, color TBD, submit sample for approval

B. Material shall be provided by supplier pre-mixed with stone dust (decomposed granite) material specified herein.

2.4 EDGING

A. Landscape edging shall be per Section 321919.16, MULCH.

PART 3 - EXECUTION

3.1 GRADING

A. Areas to receive stone dust surfacing will be compacted and brought to subgrade elevation under Section 31 20 00, EARTH MOVING before work of this section is performed. Final fine grading, furnishing and installing aggregate base course, stabilizer, and stone dust surface and compaction of these materials as required to form a firm, uniform, accurate, and unyielding stone dust surface at required elevations and to required lines, shall be done under this Section.

B. Existing subgrade material which will not readily compact as required shall be removed and replaced with satisfactory materials. Additional materials needed to bring subgrade to required line and grade and to replace unsuitable material removed shall be material conforming to Section 31 20 00, EARTH MOVING.

C. Immediately prior to paving, subgrade below exterior pavements shall be rough graded as needed, and then scarified and recompacted. This process shall include scarifying the exposed subgrade to a depth of 9 inches, moisture conditioning the scarified soil to within -2 to +3 percent of the material's optimum, and compacting the scarified soil to at least 98% of standard Proctor density (ASTM D 698). Scarified soils which cannot be recompacted to this degree should be undercut and replaced with stable material. Subgrade compaction shall extend for a distance of at least 1 ft. beyond pavement edge.

1. Field testing shall be conducted to determine in-place density, accompanied by visual inspection of the compaction methods being used.

D. Excavation required in subgrade shall be completed before fine grading and final compaction of subgrade are performed. Where excavation must be performed in completed subgrade or gravel base, subsequent backfill and compaction shall be performed as directed by the Architect as specified in Section 31 20 00, EARTH MOVING. Completed subgrade after filling such areas shall be uniformly and properly graded.

E. Areas being graded or compacted shall be kept shaped and drained during construction. Ruts greater than or equal to 1 in. deep in subgrade, shall be graded out, reshaped as required, and recompacted before placing stone dust surfacing.

F. Materials shall not be stored or stockpiled on subgrade.

G. Disposal of debris and other material excavated and/or stripped under this section, and material unsuitable for or in excess of requirements for completing work of this section shall be disposed of off-site.

3.2 EDGING

A. Landscape edging shall be installed in areas adjacent to planting areas in accordance with Section 329113.16, MULCH.

3.3 AGGREGATE BASE COURSE

A. Aggregate base course for paving and the spreading, grading, and compaction methods employed shall conform to standard requirements for usual base course of this type for first class road work, and the following:

1. MHD Specifications Section 405, "Gravel Base Course".

B. Compaction of aggregate base course shall be to 95% of maximum density as determined by ASTM D 1557, Method D. Stone greater than 2-1/2 in. shall be excluded from course.

C. Width of base course shall be greater than or equal to the width of pavement surface, if continuous lateral support is provided during rolling, and shall extend at least 2 x base thickness beyond edge of the course above, if not so supported.

D. Aggregate material shall be applied in lifts less than or equal to 6 in. thick, compacted measure. Each lift shall be separately compacted to specified density, using a 6 ton steel wheel roller or vibratory roller equivalent to a 6 ton static roller, or an approved equivalent.

1. Material shall be placed adjacent to wall, manhole, catch basin, and other structures only after they have been set to required grade and level.
2. Rolling shall begin at sides and progress to center of crowned areas, and shall begin on low side and progress toward high side of sloped areas. Rolling shall continue until material does not creep or wave ahead of roller wheels.
3. Surface irregularities which exceed 1/2 in. measured by means of a 10 ft. long straightedge shall be replaced and properly compacted.

E. Subgrade and base course shall be kept clean and uncontaminated. Less select materials shall not be permitted to become mixed with gravel. Materials spilled outside pavement lines shall be removed and area repaired.

F. Portions of subgrade or of construction above which become contaminated, softened, or dislodged by passing of traffic, or otherwise damaged, shall be cleaned, replaced, and otherwise repaired to conform to the requirements of this specification before proceeding with next operation.

3.4 STONE DUST (DECOMPOSED GRANITE) SURFACING

A. Stabilizer shall be provided thoroughly and unifomly pre-blended with decomposed granite by local supplier, at rate, and by method in strict accordance with manufacturer's printed instructions.
1. Blend 12 to 16-lbs (contact manufacturer for exact blend) of Stabilizer per 1-ton of decomposed granite or crushed aggregate screenings. It is critical that Stabilizer be thoroughly and uniformly mixed throughout decomposed granite or crushed aggregate screenings.
2. Bucket blending is not acceptable. Blending with a rake and or shovel is not acceptable.
3. Blend material dry.

B. Decomposed granite surfacing shall be done only after excavation and construction work which might injure it has been completed. Damage caused during construction shall be repaired before acceptance.

C. Decomposed granite surfacing shall be constructed on a compacted aggregate base or sand-based structural soil mix as indicated on the Drawings.

D. Pre-blended stabilized decomposed granite or crushed aggregate screenings shall be spread evenly over the base in 1-1/2 in. maximum lifts, rolled and compacted to 85% of maximum density as determined by ASTM D 1557. Final compacted thickness shal be 3 in.
1. Contractor shall wait a minimum of 24 hours after placing stabilized decomposed granite material prior to compaction. Longer periods may be required for material to adequately dry. Consult manufacturer to make determination.

E. Water shall be added to decomposed granite for full-depth moisture penetration prior to compacting.
1. Minimum 25 to 45-gallons of water per 1-ton must be applied to achieve saturation of stabilized pathway profile.

2. During water application randomly test for depth using a probing device, which reaches full depth.

F. Upon thorough moisture penetration, compact stabilized decomposed granite to 85% relative compaction with 2 to 4 ton durable drum roller or 1000 lb. single drum roller as required to achieve a dense, hard packed surface conforming to the finish grades indicated.

1. Do not use vibratory rollers or compactors.
2. Do not begin compaction for 12 hours after placement and up to 72 hours.
3. Contractor shall hand tamp areas adjacent to irrigation or plantings with 8 in. or 10 in. hand tamper.
4. If surface aggregate dries significantly quicker than subsurface material, lightly mist surface before compaction operations.

G. Variations in smoothness of finished stone dust surface shall be less than or equal to 1/4 in. when tested with a 10 ft. straightedge, applied both parallel to and at right angles to centerline of stone dust surface areas. Irregularities exceeding these amounts or which retain water on surface shall be corrected by removing defective work and replacing with new material conforming to this specification.

H. Crushed stone surface shall comply with ADA Requirements for slip resistance and accessibility, with a minimum static coefficient of friction of 0.6 for accessible routes and 0.8 for ramps, when tested in accordance with ASTM C1028.

I. Allow finished surface to dry completely before permitting use.

3.5 INSPECTION

A. Finished aggregate surfacing shall be smooth, uniform and solid. Cured and compacted aggregate shall be firm throughout profile with no spongy areas. Loose material shall not be present on the surface after installation, but may appear after use and according to environmental conditions. Aggregate shall remain stable underneath loose decomposed granite on top. Surfacing shall appear “natural” yet stable throughout. Any significant irregularities in surfacing shall be repaired to the uniformity of the entire installation.

END OF SECTION

SECTION 32 16 13
CURBS AND GUTTERS

PART 1-GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.2 DESCRIPTION OF WORK

A. Work Included: Provide labor, materials and equipment necessary to complete the work of this Section, including but not limited to the following:

1. Furnishing and installing granite curb, granite edging, curb inlets, and curb corners, precast concrete curb and cast-in-place concrete curb.
2. All associated items and operations required to complete the installations, including surface preparation, concrete support, jointing and finishing.

B. Alternates: Not Applicable.

C. Items To Be Installed Only: Not Applicable.

D. Items To Be Furnished Only: Not Applicable.

E. Related Work: The following items are not included in this Section and will be performed under the designated Sections:

1. Section 033000 – CAST-IN-PLACE CONCRETE for general construction applications of concrete.
2. Section 312000 – EARTH MOVING for aggregate subbase and base courses and for aggregate pavement shoulders.
3. Section 321313 – CONCRETE PAVING for installation of cement concrete paving for driveways, walkways, and sidewalks.
4. Section 321216 – ASPHALT PAVING for hot-mix asphalt pavement for roadways, parking lots, walkways, berms, and curbs.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

1. Submit Shop Drawings and Manufacturer's literature for granite and precast curb, edging, corners and inlets, indicating size, shape and dimensions, finish and setting method.
2. Copies of tests on representative samples of the concrete used in the manufacture of precast units showing a compressive strength of 5,000 psi.

1.4 REFERENCE STANDARDS

A. The following standards are applicable to the work of this Section to the extent referenced herein:

1. Commonwealth of Massachusetts, Massachusetts Department of Transportation (MassDOT), Highway Division, Standard Specifications for Highways and Bridges, latest English Edition with amendments. All references to method of measurement, basis of payment and payment items in the Standard Specifications are hereby deleted. References made to particular sections or paragraphs in the Standard Specifications shall include all related articles mentioned herein.
2. ANSI: American National Standards Institute
3. ASTM: American Society for Testing and Materials
4. AASHTO: American Association of State Highway and Transportation Officials
5. ACI: American Concrete Institute
6. References herein are made in accordance with the following abbreviations and, all work under this Section shall conform to the latest editions as applicable.
    a. ACI 304-Recommended Practice for measuring, mixing, transporting and placing concrete.
    b. ANSI/ASTM D1751-Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Non extruding and Resilient Bituminous Types).
    c. ANSI/ASTM D1752-Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction.
    d. ASTM A615-Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
    e. ASTM C33-Concrete Aggregates.
    f. ASTM C94-Ready-Mixed Concrete.
    g. ASTM C150-Portland Cement.
    h. ASTM C233-Stanard Test Method for Air-Entraining Admixtures for Concrete.
    i. ASTM C260-Air-Entraining Admixtures for Concrete.
    j. ASTM C309-Liquid Membrane-Forming Compounds for Curbing Concrete.
    k. ASTM C494-Chemical Admixtures for Concrete.
7. City of Worcester Department of Public Works Standard Specifications and Details, February 1, 2021 or latest edition.

1.5 DELIVERY, STORAGE AND HANDLING

A. Granite and precast curb units shall be adequately protected from damage during transit to the site.

B. Curbing shall be protected against staining, chipping, and other damage. Cracked, badly chipped, or stained units will be rejected and shall not be employed in the work.

1.6 SAMPLES

A. The Contractor shall supply to the site three samples of all curb types for approval prior to ordering materials. Approved sample material may be used in the work.

1.7 EXAMINATION OF SITE AND DOCUMENTS

A. It is hereby understood that the Contractor has carefully examined the site and all conditions affecting work under this Section. No claim for additional costs will be allowed because of a lack of knowledge of existing conditions as indicated in the Construction Documents, or obvious from observation of the site.

B. Plans, surveys, measurements, and dimensions under which the work is to be performed are believed to be correct, but the Contractor shall have examined them for himself during the bidding period and formed his own conclusions as to the full requirements of the work involved.

PART 2-PRODUCTS

2.1 GRANITE CURB

A. Granite curb shall conform to MassDOT Standard Specification Section M9.04.0: Curb and Edging.

B. Granite curb shall be basically light gray in color, free from seams and other structural imperfections or flaws which would impair its structural integrity, and of a smooth splitting appearance. Natural color variation characteristic of the deposit from which the curb is obtained will be permitted.

C. Whenever curbing is sawed, all surfaces that are to be exposed shall be thoroughly cleaned and any iron rust or iron particles removed by sand blasting or other methods satisfactory to the Owner's Representative and/or Designer and any saw mark in excess of 1/8 inch shall be removed.

D. Granite Curb. The stones for the granite curb shall be cut to the dimensions and curvature hereinafter stated:

Type	Minimum Length	Width at Top	Depth	Minimum Width at Bottom
VA4	6 ft	6 in.	17 in. to 19 in.	4 in. (for 2/3 length)

1. Stones used in making closures may be as much as one-third shorter than specified.
2. On curves with radii greater than 100 ft but less than 500 ft, VA stone may be 4 ft to not more than 6 ft in length.
3. Type VA stones to be set on a radius of 100 ft or less shall be cut to the required curvature unless otherwise directed and except for making closures shall be of minimum lengths as follows:

Radius	Minimum Length
50 ft to 100 ft	6 ft
25 ft to less than 50 ft	4.5 ft
Less than 25 ft	3 ft

4. The ends of all curved stones shall be cut on radial lines.

E. Finish

1. Granite curb shall have a top surface free from wind, shall be peen hammered or sawed to an approximately true plane, and shall have no projections or depressions greater than 1/8 inch. The front and back arris lines shall be pitched straight and true and there shall be no projection on the back surface for 3 inches down from the top which would exceed a batter of 4 inches to 1 foot.
2. The front face shall be at right angles to the planes of the top and ends and shall be smooth quarry split, free from drill holes and with no projection of more than 1 inch and no depression of more than 1/2 inch measured from the vertical plane of the face through the arris or pitch line for a distance down from the top of 8 inches. For the remaining distance, there shall be no projection or depression greater than 1 inch measured in the same manner.
3. The ends of all stones shall be square with the planes of the top and face so that when the stones are placed end to end as closely as possible, no space shall show in the joint at the top and face of more than 1/2 inch for the full width of the top and for 8 inches down on the face, after which the end may break back not over 8 inches from the plane of the joint. The arris formed by the intersection of the plane of the joint with the planes of the top and exposed faces shall have no variation from the plane of the top and exposed faces greater than 1/8 inch.
4. The ends of all transition curb shall be cut with a power-driven saw to provide a flush vertical joint with adjacent curbing.

2.2 GRANITE EDGING – NOT USED

2.3 GRANITE CURB INLETS

A. The granite for curb inlet shall conform to MassDOT Standard Specification Section M9.04.0: Curb and Edging.

B. Granite inlet stones shall be as supplied by H.E. Fletcher Company of Westford, MA or approved equal.

C. It shall have a horizontal bed and the top shall be free from wind. The stone shall be sawn or peen hammered on top and the front and back edges shall be pitched true to line. The back face for a distance of 3 in. down from the top shall have no projection greater than 1 in. The front face shall be straight split, free from drill holes, and it shall have no projection greater than 1 in or depression greater than 0.5 in. for a distance of 10 in. down from the top, and for the remaining distance there shall be no depression or projection greater than 1 in. The ends shall be squared with the top for the depth of the face finish and so cut that the curb inlet can be set with joints of not more than 1/2 in.

D. The granite curb inlet shall be 54 inches in length +/- 1/2 in., 15 inches. in depth, 12 inches wide at the top and 4 inches wide at the bottom (back of curb).

E. Curb inlets to be set on a radius of 160 ft or less shall be cut to the curve required, unless otherwise directed by the Engineer. The joints of all curved curb inlets shall be cut on radial lines.

F. A gutter mouth 11 inches in height, 8 inches in depth, and 30 inches in length shall be cut in the front face of the stone.

G. Granite curb inlets shall match the adjacent curbing in color.

2.4 GRANITE CURB CORNERS

A. The granite for curb corners shall conform to MassDOT Standard Specification Section M9.04.0: Curb and Edging.

B. Curb corners shall have horizontal beds and match the adjacent curbing in size, color and quality. The front arris lines shall extend through one-quarter of a circle having a radius of 2 ft or 3 ft respectively for Type A or Type B Curb Corner. The back arris line shall be straight. The plane of back shall be normal to top.

2.5 PRECAST CONCRETE CURB – NOT USED

2.6 CAST-IN-PLACE CONCRETE CURB – NOT USED

2.7 CEMENT MORTAR

A. Cement mortar shall be composed of one (1) part Portland Cement and two (2) parts sand by volume with sufficient water to form a workable mix. Cement shall be Portland Cement Type II.

2.8 TRANSITION CURB

A. Horizontal transition sections shall be provided at all locations where curb sections change (i.e. vertical curb to sloped curb).

B. Vertical transition sections shall be provided for transitions from normal curb setting to pedestrian ramps. Transitions shall be the same type of curb and similar to that abutting and, if on a curve, of the same radius.

PART 3-EXECUTION

3.1 GENERAL

A. Curb, edging, curb inlet and curb corner units delivered to the site shall be inspected for damage, unloaded and placed along the prepared curb trench, or other designated location, with the minimum amount of handling.

1. Materials shall be handled in a manner that prevents damage to the units.
2. All individual pieces of curved curbing shall be marked to correspond to the radius and location where curbing is to be set.

B. Trenching, excavation, backfilling, and compaction shall be completed in accordance with Section 312000 – EARTH MOVING.

3.2 CURB INSTALLATION

A. Excavating Trench.

1. The trench for curb shall be excavated to a width of 18 inches.

2. The subgrade of the trench shall be a depth below the proposed finished grade of the curb equal to 6 inches plus the depth of the curb unit.
3. Existing pavements shall be sawcut in

B. Preparing Foundation.

1. The foundation for the curb shall consist of gravel spread upon the subgrade and after being thoroughly compacted by tamping shall be 6 inches in depth.
2. The gravel foundation for edging shall be as shown on the plans and shall be thoroughly rammed or tamped until firm and unyielding.
3. The foundation for curb inlets shall consist of a full bed of Portland cement mortar on the supporting back wall of the catch basin or gutter inlet and sufficient gravel on each side to support the overhang. The trench for the gravel foundation shall be at least 6 inches in depth and 18 inches in width. This trench shall be filled with gravel thoroughly tamped to the required grade.
4. The trench for curb corners shall be excavated so that there shall be constructed a foundation of gravel which when thoroughly compacted will be 6 inches in depth and extending 6 inches beyond the front and back of curb corner to the full depths of foundation. Other acceptable material may be used for backing.

C. Setting Curb and Edging.

1. Curbing, curb corners or edging shall be set on additional gravel spread upon the foundation.
2. All spaces under the curb, curb corners or edging shall be filled with gravel thoroughly compacted so that the curb, curb corners or edging will be completely supported throughout their length. The curb shall be set at the line and grade required as shown on the plans unless otherwise directed by the Owner's Representative and/or the Designer.
3. The curbing shall be set on edge and settled into place with a heavy wooden hand-rammer, to the line and grade required, straight and true for the full depth.
4. Curb, curb corners or edging shall be fitted together as closely as possible.
5. If granite curb, curb corners, curb inlets or edging of different quarries is used on the same project, curbing of each particular quarry shall be segregated and set to give uniform appearance.
6. The ends of the granite curb at driveways and intersections shall be cut at a bevel or rounded, as indicated on the Contract Drawings.
7. Pedestrian ramps and flush curb sections shall be constructed with transition sections, as indicated on the Contract Drawings.
8. Precast concrete curb units shall be doweled together continuously to the line and grade indicated on the Contract Drawings.

D. Filling About Trench.

1. After the curb, curb corners, curb inlets, and edging is set, the space between it and the wall of the trench shall be filled with cement concrete as indicated on the Contract Drawings. Care shall be taken in placing the concrete to avoid disturbing the line or grade of the curb.

2. After the concrete has sufficiently cured, the space between the back of curb and the wall of the trench shall be filled with gravel borrow compacted to the depth indicated on Contract Drawings.

E. Pointing

1. The joints between curbstones (both front and back) or edging shall be carefully filled with cement mortar and neatly pointed on the top and front exposed portions. After pointing, the curbstones and edging shall be satisfactorily cleaned of all excess mortar.

3.3 REMOVAL AND RESETTING OF CURB

A. Procedures for removal and resetting of existing granite curb, and new granite curb, in existing pavements shall include the following:

1. Prior to excavation for existing granite curb removal, the pavement surface shall be cut a minimum of one foot from the face of curb with appropriate pavement cutting equipment.
2. Existing curb shall be carefully excavated and removed in a manner that protects the curb and existing pavement to remain from damage.
3. Existing granite curb shall be cleaned by sandblasting as required to remove of bituminous material, paint and concrete from exposed surfaces prior to resetting in the proposed work.
4. New granite curb shall be set to match the top of existing granite curb remaining in place at abutting sections and, if required, transitioned to the typical section shown on the Contract Drawings within the first section of curb.

3.4 CAST-IN-PLACE CONCRETE CURB – NOT USED

3.5 DISPOSAL

A. Except for material indicated to be recycled, remove excavated materials from the Project site, and legally dispose of them in an EPA-approved landfill.

End of Section

SECTION 32 17 23
PAVEMENT MARKINGS

PART 1-GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01 - GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.2 DESCRIPTION OF WORK

A. Work Included: Provide labor, materials and equipment necessary to complete the work of this Section, including but not limited to the following:

1. Furnishing and placing of the pavement markings as indicated on the Contract Drawings and as herein specified.
2. All associated items and operations required to complete the installations, including layout of work, surface preparation, application of markings, protection of markings, and accommodations for traffic.

B. Alternates: Not Applicable.

C. Items To Be Installed Only: Not Applicable.

D. Items To Be Furnished Only: Not Applicable.

E. Related Work: The following items are not included in this Section and will be performed under the designated Sections:

1. Section 321313 – CONCRETE PAVING for installation of cement concrete paving for driveways, walkways, and sidewalks.
2. Section 321216 – ASPHALT PAVING for hot-mix asphalt pavement for roadways, parking lots, walkways, berms, and curbs.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

1. Product Data: For each type of traffic and zone marking paint product. Include technical data and tested physical and performance properties.
2. Shop Drawings: Indicate pavement markings, lane separation, and defined parking spaces. Indicate, with international symbol of accessibility, spaces allocated for people with disabilities.

1.4 REFERENCE STANDARDS

A. The following standards are applicable to the work of this Section to the extent referenced herein:

1. Commonwealth of Massachusetts, Massachusetts Department of Transportation (MassDOT), Highway Division, Standard Specifications for Highways and Bridges, latest English Edition with amendments. All references to method of measurement, basis of payment and payment items in the Standard Specifications are hereby deleted. References made to particular sections or paragraphs in the Standard Specifications shall include all related articles mentioned herein.
2. MUTCD: Manual on Uniform Traffic Control Devices.

1.5 DELIVERY, STORAGE AND HANDLING

A. Deliver pavement-marking materials to Project site in original packages with seals unbroken and bearing manufacturer's labels containing brand name and type of material, date of manufacture, and directions for storage.

B. Store pavement-marking materials in a clean, dry, protected location within temperature range required by manufacturer. Protect stored materials from direct sunlight.

1.6 EXAMINATION OF SITE AND DOCUMENTS

A. It is hereby understood that the Contractor has carefully examined the site and all conditions affecting work under this Section. No claim for additional costs will be allowed because of a lack of knowledge of existing conditions as indicated in the Construction Documents, or obvious from observation of the site.

B. Plans, surveys, measurements, and dimensions under which the work is to be performed are believed to be correct, but the Contractor shall have examined them for himself during the bidding period and formed his own conclusions as to the full requirements of the work involved.

1.7 QUALITY ASSURANCE

A. Installer Qualifications: A qualified pavement marking installer whose work has resulted in successful establishment pavement markings.
1. Installer’s Field Supervisions: Require Installer to maintain an experienced full-time supervisor on Project Site when work is in progress.

B. Pavement markings shall be in accordance with the MUTCD.

1.8 PROJECT CONDITIONS

A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

B. Weather Limitations: Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature of 55 deg F for water-based materials, and not exceeding 95 deg F.

PART 2-PRODUCTS

2.1 FAST DRYING WATER-BORNE TRAFFIC PAINT

A. Fast Drying White Water-borne Traffic Paint and Fast Drying Yellow Water-borne Traffic Paint as specified in the MassDOT Standard Specification Sections M7.01.23 and M7.01.24, respectively. Traffic paint shall be lead free, VOC compliant, fast drying, 100% acrylic waterborne traffic paint. Traffic paint shall conform to the performance specifications referenced in Federal Specification TT-P-1952E Type I & II, Federal Specification TT-P-195F Type I & II.

B. Pavement markings shall be “white” or “yellow” in color, unless otherwise noted on Contract Drawings.

C. General pavement marking delineation for parking stalls shall measure 4 inches in width. All other pavement-marking widths are shown in detail on the Contract Drawings.

PART 3-EXECUTION

3.1 GENERAL

A. Pavement markings shall be applied in accordance with MassDOT Standard Specification Section 860 and in accordance with the manufacturer’s specifications and requirements.

B. Do not apply pavement-parking paint until layout, colors, and placement have been verified with the Owner’s Representative and/or the Designer.

3.2 SURFACE CONDITION AND PREPARATION

A. Asphalt and concrete surfaces shall be cured, clean, dry, and sound. The surface shall be free of sand, grease, oil or other foreign substances.

B. Prior to application of traffic paint the Contractor shall:

1. Sweep and clean pavement surface to eliminate loose material and dust.
2. Remove loose and lifting paint.
3. Remove by etching or abrasive blasting concrete pavement with sealers containing silicone, having a smooth finish, efflorescence or other conditions that may interfere with adhesion.

C. Allow new asphalt surfaces to cure for one (1) to two (2) weeks before application of traffic paint.

3.3 APPLICATION

A. Pavement markings shall be applied only in seasonable weather and in accordance with good painting practices. Apply when air and surface temperatures are above 50ºF and relative humidity is below 85%. If work has started and air temperatures fall below 50ºF and continuous cooling is forecasted, work shall be stopped. Starting work at air temperatures lower than 50ºF shall not be allowed.

B. Contractor shall apply paint with mechanical equipment to produce pavement markings, of dimensions indicated, with uniform, straight edges. Apply at manufacturer's recommended rates to provide a minimum wet film thickness of 15 mils. When the paint must be applied on new asphalt, apply two thin coats 7-8 mils each, allowing 24 hours between coats.

C. No thinners shall be used for pavement marking applications.

D. To improve spraying, Contractor may heat paint to the optimum temperature specified by the manufacturer. No paint material shall be heated above the temperature specified by the manufacturer.

E. If for any reason material is spilled or tracked on the pavement, or any markings applied by the Contractor fail to conform to the Contract Documents because of a deviation from the required pattern, the Contractor shall remove such material by a method that is not injurious to the roadway surface and is acceptable to the Owner's Representative and/or the Designer, clean the pavement surface and prepare the surface for a reapplication of markings and reapply the markings as indicated on the Contract Documents without additional compensation for any of the foregoing corrective operations.

F. Contractor shall protect pavement markings until sufficiently dry to bear traffic.

3.4 INSPECTION

A. All materials and each part or detail of the work shall be subject to observation by the Owner's Representative and/or the Designer. The Owner's Representative and/or the Designer shall be allowed access to all parts of the work and shall be furnished with such information and assistance by the Contractor as is required to make a complete and detailed inspection, (such assistance may include furnishing labor, tools, and equipment, at no expense to the Owner).

B. Any work done or materials used without authorization by the Owner's Representative and/or the Designer may be ordered removed and replaced at the Contractor's expense. The Contractor shall furnish written information to the Owner's Representative and/or the Designer stating the original sources of supply of the materials manufactured away from the actual site of the work. In order to ensure a proper time sequence for required inspection and approval this information shall be furnished at least two weeks (or as otherwise directed by the Owner's Representative and/or the Designer) in advance of the incorporation in the work of any such materials.

C. For the purpose of observing work that affects their respective properties, inspectors for the municipalities, public agencies and the utility companies shall be permitted access to the work, but all official orders and directives to the Contractor will be issued by the Owner's Representative and/or the Designer.

D. The observation of the work shall not relieve the Contractor of any of his obligations to fulfill the terms of the Contract as herein prescribed by the Contract Documents.

E. Failure to reject any defective work or materials shall not in any way prevent later rejection when such defect is discovered or obligate the Owner's Representative and/or the Designer to make final acceptance.

End of Section

Section 32 12 93.10

ARTIFICIAL GRASS FIELDTURF

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01, GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.2 DESCRIPTION OF WORK

A. Furnish all labor, materials, tools and equipment necessary to install monofilament artificial grass FieldTurf as indicated on the plans and as specified herein; including components and accessories required for a complete installation including but not limited to:

1. Acceptance of prepared sub-base.
2. Coordination with related trades to ensure a complete, integrated, and timely installation: Aggregate base course, sub-base material (tested for permeability), grading and compacting, piping and drain components; as provided under its respective trade section. Ensure below field drainage system does not conflict with any footings, foundations or other site elements.

1.3 RELATED SECTIONS

A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that directly relate to work of this Section include, but are not limited to:

1. Section 31 20 00, EARTHWORK.
2. Section 32 91 19, LANDSCAPE GRADING.
3. Section 03 30 01, CAST-IN-PLACE CONCRETE – SITEWORK.
4. Section 11 68 33, ATHLETIC EQUIPMENT.
5. Section 32 31 13, CHAIN LINK FENCE AND GATES.

1.4 REFERENCES

A. Comply with applicable requirements of the following standards. Where these standards conflict with other specified requirements, the most restrictive shall govern:

1. FM Factory Mutual
   a. P7825 - Approval Guide; Factory Mutual Research Corporation; current edition
2. ASTM – American Society for Testing and Materials.
   a. D1577 - Standard Test Method for Linear Density of Textile Fiber
   b. D5848 - Standard Test Method for Mass Per Unit Area of Pile Yarn Floor Covering
   c. D1338 - Standard Test Method for Tuft Bind of Pile Yarn Floor Covering

d. D1682 - Standard Method of Test for Breaking Load and Elongation of Textile Fabrics

e. D5034 - Standard Test Method of Breaking Strength and Elongation of Textile Fabrics (Grab Test)

f. F1015 - Standard Test Method for Relative Abrasiveness of Synthetic Turf Playing Surfaces

g. D4491 - Standard Test Methods for Water Permeability of Geotextiles by Permittivity

h. D2859 - Standard Test Method for Ignition Characteristics of Finished Textile Floor Covering Materials

i. F355 - Standard Test Method for Shock-Absorbing Properties of Playing Surfaces.

j. F1936 - Standard Test Method for Shock-Absorbing Properties of North American Football Field Playing Systems as Measured in the Field

1.5 QUALITY ASSURANCE

A. Comply with SECTION 01 43 00, QUALITY ASSURANCE.

B. Manufacturer qualifications: company specializing in manufacturing products specified in this section. The turf contractor and/or the turf manufacturer:

1. Shall be experienced in the manufacture and installation of specified type of infilled monofilament synthetic grass system for a minimum of three years. This includes a monofilament fiber, backing, the backing coating, and the installation method.
2. The manufacturer must have ISO 9001, ISO 14001 and OHSAS 18001 certifications demonstrating its manufacturing efficiency with regards to quality, environment and safety management systems.
3. Shall have a minimum of 5 installations in the State of Massachusetts.
4. The fiber and turf carpet being proposed must have a documented Fiber Performance Index of at least 80. Official testing to be completed by Labosport.
5. Artificial turf fiber proposed for the field(s) must have successfully undergone a minimum of 150,000 cycles on the Lisport wear tester, certified by an independent third party (ex: Labosport, Sports Labs, Penn State University).
6. Manufacturer must provide proof that its turf systems have been subject to long-term independent, epidemiological and peer reviewed studies proving its ability to provide for a safe surface.

C. Installer: Company shall specialize in performing the work of this section. The Contractor shall provide competent workmen skilled in this specific type of synthetic grass installation.

1. The designated Supervisory Personnel on the project shall be certified, in writing by the turf manufacturer, as competent in the installation of specified monofilament material, including sewing seams and proper installation of the infill mixture.
2. Installer shall be certified by the manufacturer and licensed.

3. The installer supervisor shall have a minimum of 5 years' experience as either a construction manager or a supervisor of synthetic turf installations

D. Pre-Installation Conference: Conduct conference at project site at time to be determined by Architect. Review methods and procedures related to installation including, but not limited to, the following:

1. Inspect and discuss existing conditions and preparatory work performed under other contracts.
2. In addition to the Contractor and the installer, arrange for the attendance of installers affected by the Work, The Owner's representative, and the Architect.

E. The Contractor shall verify special conditions required for the installation of the system.

F. The Contractor shall notify the Architect of any discrepancies.

1.6 SUBMITTALS

A. Substitutions: Other products are acceptable if in compliance with all requirements of these specifications. Submit alternate products with all submittal requirements to Architect for approval 10 days prior to bidding in accordance with Product Substitution Procedures. Design Approval: The owner / landscape architect will review pre-bid submittals from all non-approved manufactures to ensure compliance to the specification 10 days prior to bid. If the system meets the system requirements of the specifications, a letter and/or addendum will be issued to the manufacturer indicating approval for the system submitted.

1. Verification
   a. Provide substantiation that proposed system does not violate any other manufacturer's patents, patents allowed or patents pending.
   b. Provide a sample copy of insured, non-prorated warranty and insurance policy information.
2. Shop Drawings:
   a. Indicate field layout; field marking plan and details for the specified sports; i.e., NCAA Football; roll/seaming layout; methods of attachment, field openings and perimeter conditions.
   b. Show installation methods and construction indicating field verified conditions, clearances, measurements, terminations, drainage.
   c. Provide joint submission with related trades when requested by Architect.
3. Product Data: Due at time of Bid
   a. Submit manufacturer's catalog cuts, material safety data sheets (MSDS), brochures, specifications; preparation and installation instructions and recommendations; storage, handling requirements and recommendations.
   b. Submit fiber manufacturer's name, type of fiber and composition of fiber.
   c. Submit cryogenic suppliers name, sieve analysis and origin of materials.
   d. Submit data in sufficient detail to indicate compliance with the contract documents.

e. Submit manufacturer's instructions for installation.

f. Submit manufacturer's instructions for maintenance for the proper care and preventative maintenance of the synthetic turf system, including painting and markings.

4. Samples: Due at time of Bid. Submit samples, 9 x 12 inches, illustrating details of finished product in amounts as required by General Requirements, or as requested by Architect.

5. Product Certification: Due at time of Bid

   a. Submit manufacturer's certification that products and materials comply with requirements of the specifications.

   b. Submit test results indicating compliance with Reference Standards.

6. Project Record Documents: Record actual locations of seams, drains and other pertinent information in accordance with Specifications, General Requirements.

7. List of existing installations: Due at time of Bid. Submit list including respective Owner's representative and telephone number. (min. 3)

8. Warranties: Submit warranty and ensure that forms have been completed in Owner's name and registered with approved manufacturer.

9. Submit Bills of Lading/Material Delivery Receipts for synthetic turf infill materials. Bills of lading shall bear the name of the project/delivery address, quantity of materials delivered, source/location of origin of infill materials and/or manufacturer, and date of delivery.

10. Testing Certification: Due at time of Bid. Submit certified copies of independent (third-party) laboratory reports on ASTM testing:

    a. Pile Height, Face Weight & Total Fabric Weight, ASTM D5848.

    b. Primary & Secondary Backing Weights, ASTM D5848.

    c. Tuft Bind, ASTM D1335.

    d. Grab Tear Strength, ASTM D1682 or D5034.

    e. Water Permeability, ASTM D4491

11. The Turf Vendor shall submit a document holding the Owner and its representatives harmless as to any liability and or costs of any type, including but not limited to legal costs, royalties, replacement costs, etc. associated with any claim by the Turf Vendor or others associated and with any patents or infringements of any current or future patent issued for the synthetic turf product, infill materials, installation methods or drainage characteristics. It is not the intent of these documents to promote or induce the use of intellectual property belonging to others or promote infringement of any known or currently not known patents, licenses or rights of others.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Comply with Section 01 60 00, Product Requirements.

B. Prevent contact with materials that may cause dysfunction.

C. Deliver and store components with labels intact and legible.

D. Store materials/components in a safe place, under cover, and elevated above grade.

E. Protect from damage during delivery, storage, handling and installation. Protect from damage by other trades.

F. Inspect all delivered materials and products to ensure they are undamaged and in good condition.

G. Comply with manufacturer's recommendations.

1.8 SEQUENCING AND SCHEDULING

A. Coordinate the Work with installation of work of related trades as the Work proceeds.

B. Sequence the Work in order to prevent deterioration of installed system.

1.9 WARRANTY AND GUARANTEE

A. See Section 01 77 00 - Closeout Submittals, For Additional Warranty Requirements.

B. The Contractor shall provide a warranty to the Owner that covers defects in materials and workmanship of the turf for a period of eight (8) years from the date of substantial completion. The turf manufacturer must verify that their representative has inspected the installation and that the work conforms to the manufacturer's requirements. The manufacturer's warranty shall include general wear and damage caused from UV degradation. The warranty shall specifically exclude vandalism, and acts of God beyond the control of the Owner or the manufacturer. The warranty shall be fully third party insured; prepaid for the entire 8 year term and be non-prorated. The Contractor shall provide a warranty to the Owner that covers defects in the installation workmanship, and further warrant that the installation was done in accordance with both the manufacturer's recommendations and any written directives of the manufacturer's representative. Prior to final payment for the synthetic turf, the Contractor shall submit to owner notification in writing that the field is officially added to the annual policy coverage, guaranteeing the warranty to the Owner. The insurance policy must be underwritten by an "AM Best" A rated carrier and must reflect the following values:

1. Pre-Paid 8-year insured warranty from a single source.
2. Maximum per claim coverage amount of $15,000,000.
3. Minimum of fifteen million dollars ($15,000,000) annual.
4. Must cover full 100% replacement value of total square footage installed, minimum of $7.00 per sq ft. (in case of complete product failure, which will include removal and disposal of the existing surface)
5. Provide a sample copy of insured, non-prorated warranty and insurance policy information.
6. Policy cannot include any form of deductible to be paid by the Owner.

C. The artificial grass system must maintain a G-max of less than 200 for the life of the Warranty as per ASTM F1936.

1.10 MAINTENANCE SERVICE

A. Contractor shall train the Owner's facility maintenance staff in the use of the turf manufacturer's recommended maintenance equipment.

B. Manufacturer must provide maintenance guidelines and a maintenance video to the facility maintenance staff.

1.11 SUB-BASE DRAINAGE TEST

A. Installed sub-base shall be tested for porosity prior to the installation of the monofilament turf. A sub base that drains poorly is an unacceptable substrate.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURER

A. Approved manufacturers are as follows:

1. FieldTurf USA Inc., 75 N. Industrial Blvd, Calhoun, GA 30701, P: 800-724-2969
   a. Model: FieldTurf Core 2.5" 'Coolplay' Infill material
2. Matrix Turf by Hellas Construction, Inc, 12710 Research Boulevard Suite 240, Austin , TX 78759, p: 512.250.2910. www.matrixturf.com
3. Greenfields USA, 1131 Broadway St, Dayton, TN p: 855.773.6668, www.Greenfields.com
4. Sporturf, 200 Howell Drive, Dalton, Georgia 30721, p: (800) 798-1056, Sporturf.com

2.2 MATERIALS AND PRODUCTS

A. Artificial grass Turf system materials shall consist of the following:

1. Carpet made of monofilament polyethylene fibers tufted into a fibrous, non-perforated, porous backing.
2. Infill: graded sand and organic crumb that partially covers the carpet.
3. Glue, thread, paint, seaming fabric and other materials used to install and mark the artificial grass monofilament FieldTurf.

B. The installed artificial grass monofilament Turf shall have the following properties:

Standard	Property	Specification
ASTM D1577	Fiber Denier	14,000
ASTM D5823	Min. Pile Height	2 1/2”
ASTM D1577	Fiber Thickness	380 Microns
ASTM D5793	Stitch Gauge	3/4”
ASTM D5848	Pile Weight	42oz/square yard
ASTM D5848	Primary Backing	7+oz/square yard
ASTM D5848	Secondary Backing	14+oz/square yard
ASTM D5848	Total Weight	63+oz/square yard
ASTM D1335	Tuft Bind (Without Infill)	8+ lbs.
ASTM D5034	Grab Tear (Width)	200 lbs./force
ASTM D5034	Grab Tear (Length)	200 lbs./force
ASTM D4491	Carpet Permeability	>40 inches/hour
ASTM F1936	Impact Attenuation (Gmax)	<200
	Min. Infill Material Depth	1.75 inches
	Min. Sand Infill Component	6.2lbs/sq. ft.
	Min. Cryogenic Rubber Infill	3lbs/sq. ft.
	Total Product Weight	1388oz/sq. yd.

Variation of +/- 5% on above listed properties is within normal manufacturing tolerances

C. Carpet shall consist of monofilament fibers tufted into a primary backing with a secondary backing.

D. Carpet Rolls shall be 15’ wide rolls.
   1. Rolls shall be long enough to go from field sideline to sideline.
   2. Where the playing field is for football, the perimeter white line shall be tufted into the individual sideline rolls.

E. Backing:
   1. Primary backing shall be a minimum double-layered polypropylene fabric
   2. Secondary backing shall permanently lock the fiber tufts in place.
   3. Perforated (with punched holes), backed carpet are unacceptable.

F. Fiber shall be measuring no less than 2 ½ inches high. Fiber shall be 14,000 denier, low friction, UV-resistant. Each monofilament fiber is extruded with two layers of polyethylene polymers. A rigid polyethylene polymer as the inner core of the fiber for superior resilience and a soft yet extremely durable polyethylene polymer as the outer shell of the fiber for a realistic grass-like feel.
   1. Systems with less than a 2 ½ inch fibers are unacceptable.
   2. Infill shall consist of a resilient granular system comprising selected and graded sand, an ambient SBR rubber processed through a rubber cracked

mill at ambient temperature below an extruded composite top dressing designed to reduce heat.

3. Artificial Grass products without cryogenically or cracked mill processed rubber shall not be accepted.

G. The sand infill will comply within the following characteristics:

1. Average Particle size between 20 and 30 mesh [calculated based on summing the midpoint of sieve pan fractions times the % retained on given screen fractions]
2. Average Particle shape > 0.4 on the Krumbein scale
3. Particle structure predominantly single grain
4. Produce < 0.4%, -50M in API crush test at 80psig

H. Field lines to be tufted into material as noted on the drawings.

I. If directed by the Owner, any additional non-tufted or inlaid lines and markings (not shown on the drawings) shall be painted with paint approved by the synthetic turf manufacturer.

J. Thread for sewing seams of turf shall be as recommended by the synthetic turf manufacturer.

K. Glue and seaming fabric for inlaying lines and markings shall be as recommended by the synthetic turf manufacturer.

2.3 QUALITY CONTROL IN MANUFACTURING

A. The manufacturer shall own and operate its own manufacturing plant. Manufacturing the fiber, tufting of the field fibers into the backing materials and coating of the turf system must be done in-house by the turf manufacturer. Outsourcing of any of these major processes is unacceptable.

B. The manufacturer shall have full-time certified in-house inspectors at their manufacturing plant that are experts with industry standards.

C. Primary backing shall be inspected by the manufacturer’s full-time certified in-house inspectors before tufting begins.

D. The manufacturer’s full-time in-house certified inspectors shall verify “pick count”, yarn density in relation to the backing, to ensure the accurate amount of face yarn per square inch.

E. The manufacturer’s full-time, in-house, certified inspectors shall perform turf inspections at all levels of production including during the tufting process and at the final stages before the turf is loaded onto the truck for delivery.

F. The manufacturer shall have its own, in-house laboratory where samples of turf are retained and analyzed, based on standard industry tests, performed by full-time, in-house, certified inspectors.

G. The manufacturer must have ISO 9001, ISO 14001 and OHSAS 18001 certifications demonstrating its manufacturing efficiency with regards to quality, environment and safety management systems.

2.4 FIELD GROOMER & SWEEPER

A. Supply to owner field groomer as part of the work.

1. Field Groomer: Greensgroomer 920SDE or equal shall include a towing attachment compatible with a field utility vehicle.
2. Field Sweeper: Greensgroomer Litterkat 760 or equal shall include a towing attachment compatible with a field utility vehicle.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that all sub-base leveling is complete prior to installation.

B. Installer shall examine the surface to receive the synthetic turf and accept the sub-base planarity in writing prior to the beginning of installation.

1. Acceptance is dependent upon the Owner's test results indicating compaction and planarity are in compliance with manufacturer's specifications.
2. The surface shall be accepted by Installer as "clean" as installation commences and shall be maintained in that condition throughout the process.

C. Compaction of the aggregate base shall be 95%, in accordance with ASTM D1557 (Modified Proctor procedure); and the surface tolerance shall not exceed 0-1/4 inch over 10 feet and 0-½" from design grade.

D. Correct conditions detrimental to timely and proper completion of Work.

E. Do not proceed until unsatisfactory conditions are corrected.

F. Beginning of installation means acceptance of existing conditions.

3.2 PREPARATION

A. Prior to the beginning of installation, inspect the sub-base for tolerance to grade.

B. Sub-base acceptance shall be subject to receipt of test results (by others) for compaction and planarity that sub-base is in compliance with manufacturer's specifications and recommendations.

C. Dimensions of the field and locations for markings shall be measured by a registered surveyor to verify conformity to the specifications and applicable standards. A record of the finished field as-built measurements shall be made.

3.3 INSTALLATION - GENERAL

A. The installation shall be performed in full compliance with approved Shop Drawings.

B. Only trained technicians, skilled in the installation of athletic caliber synthetic turf system working under the direct supervision of the approved installer supervisors, shall undertake any cutting, sewing, gluing, shearing, and topdressing or brushing operations.

C. The designated Supervisory personnel on the project must be certified, in writing by the turf manufacturer, as competent in the installation of this material, including sewing seams and proper installation of the Infill mixture.

D. Designs, markings, layouts, and materials shall conform to all currently applicable National Collegiate Athletic Association rules, NFHS rules, and/or other rules or standards that may apply to this type of synthetic grass installation. Designs, markings and layouts shall first be approved by the Architect or Owner in the form of final shop drawings. All markings will be in full compliance with final shop drawings.

3.4 INSTALLATION

A. Install at location(s) indicated, to comply with final shop drawings, manufacturers'/installer's instructions.

B. The Contractor shall strictly adhere to specified procedures. Any variance from these requirements shall be provided in writing, by the manufacturer's on-site representative, and submitted to the Architect and/or Owner, verifying that the changes do not in any way affect the Warranty. Infill materials shall be approved by the manufacturer and installed in accordance with the manufacturer's standard procedures.

C. Carpet rolls shall be installed directly over the properly prepared aggregate base. Extreme care shall be taken to avoid disturbing the aggregate base, both in regard to compaction and planarity.

1. Repair and properly compact any disturbed areas of the aggregate base as recommended by manufacturer

D. Full width rolls shall be laid out across the field.

1. Turf shall be of sufficient length to permit full cross-field installation from sideline to sideline.
2. No cross seams will be allowed in the main playing area between the sidelines.
3. Each roll shall be attached to the next roll utilizing standard state-of-the- art sewing procedures.
4. When all of the rolls of the playing surface have been installed, the sideline areas shall be installed at right angles to the playing surface.

E. Artificial turf panel seams shall be sewn along the selvedge edging flap of the turf roll. Seams secured by other means including gluing are unacceptable. Installation shall be 99% sewn.

1. Minimum gluing will only be permitted to repair problem areas, corner completions, and to cut in any logos or inlaid lines as required by the specifications.
2. Seams shall be flat, tight, and permanent with no separation or fraying.
3. In the case of all lines and logos, turf carpet/field fibers must be sheared to the backing (do not cut the backing) and adhered using hot melt adhesives.

F. Infill Materials:

1. Infill materials shall be applied in numerous thin lifts. The turf shall be brushed as the mixture is applied.
2. Infill materials shall be installed to fill the voids between the fibers and allow the fibers to remain vertical and non-directional. The Infill installation consists of sand and cryogenically processed rubber. The Infill shall be installed to a minimum depth of 1 3/4".

G. All playfield lines are to be tufted in the material, no painted lines.

H. Synthetic turf shall be attached to the perimeter edge detail in accordance with the manufacturer's standard procedures.

I. Upon completion of installation, the finished field shall be inspected by the installation crew and an installation supervisor.

3.5 FIELD MARKINGS

A. Submit shop drawings for approval of all field markings prior to fabrication.

B. The following sports will be tufted-in to the field in order of priority. See drawings for layout, sizing and color designations.
1. Football
2. Soccer
3. Field hockey
4. Lacrosse

3.6 ADJUSTMENT AND CLEANING

A. Do not permit traffic over unprotected surface.

B. Contractor shall provide the labor, supplies, and equipment as necessary for final cleaning of surfaces and installed items.

C. All usable remnants of new material shall become the property of the Owner.

D. The Contractor shall keep the area clean throughout the project and clear of debris.

E. Surfaces, recesses, enclosures, and related spaces shall be cleaned as necessary to leave the work area in a clean, immaculate condition ready for immediate occupancy and use by the Owner.

3.7 PROTECTION

A. Protect installation throughout construction process until date of final completion.

END OF SECTION

Section 32 31 13

CHAIN LINK FENCES AND GATES

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01, GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.2 DESCRIPTION OF WORK

A. Provide all equipment and materials, and do all work necessary to construct the chain link fence and gate and cantilever slide gate, as indicated on the Drawings and as specified.

1.3 RELATED SECTIONS

A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that directly relate to work of this Section include, but are not limited to:

1. Section 033001, CAST-IN-PLACE CONCRETE - SITEWORK.
2. Section 116833, ATHLETIC EQUIPMENT – Ball Safety Netting in various locations
3. Section 312000, EARTH MOVING.
4. Section 32 13 13, CONCRETE PAVEMENT - PEDESTRIAN

1.4 REFERENCES

A. Comply with applicable requirements of the following standards. Where these standards conflict with other specified requirements, the most restrictive shall govern:

1. American Society for Testing and Materials (ASTM):

A 53 Pipe, Steel, Black and Hot-Dipped Zinc-Coated Welded and Seamless

A 90 Weight of Coating on Zinc-Coated (Galvanized) Iron or Steel Articles

A 123 Zinc (Hot-Galvanized) Coatings on Products Fabricated from Rolled, Pressed, and Forged Steel Shapes, Plates, Bars, and Strip

A 153 Zinc-Coating (Hot-Dip) on Iron and Steel Hardware

A 385 High-Quality Zinc Coatings (Hot-Dip)

A 392 Zinc-Coated Steel Chain-Link Fence Fabric

A 569 Steel, Carbon (0.15 Maximum Percent) Hot-Rolled Sheet and Strip, Commercial Quality

B 6 Zinc (Slab Zinc)

F 567 Installation of Chain-Link Fence

F 668 Poly (Vinyl Chloride)(PVC)-Coated Steel Chain- Link Fence Fabric

2. Chain Link Fence Manufacturers Institute (CLFMI): \

Manual Product Manual

1.5 QUALITY ASSURANCE

A. Galvanized steel chain link fencing shall be manufactured in accordance with the requirements of the CLFMI Manual. Fence manufacturer shall be a CLFMI member.

B. Fence manufacturer shall have at least ten years of experience in the manufacture of galvanized steel chain link fencing.

1.6 SUBMITTALS

A. Information and Review Submittals: Submit the following under provisions of Section 01 33 00 - SUBMITTAL PROCEDURES:

B. Product Data: For each type of product indicated. Include technical data and tested physical and performance properties.

1. Each fence fabric type
2. Each size of pipe
3. Each type of hardware and fitting
4. Gates, including latch
5. All rails, bracing, tracks, and guide posts
6. All components for the wheel assemblies, truck assemblies, and any other components for the cantilever slide gate
7. Manufacturer’s vinyl coating system
8. The fence contractor shall provide the fence manufacturer's notarized certification to the Owner’s Representative that the vinyl-coated chain link fabric is warranted by the manufacturer for a minimum of 15 years against rust and corrosion.

C. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work. Show accessories, hardware, gate operation, and operational clearances.

1. Provide a complete and detailed layout showing all chain link fence post locations.
2. Submit a complete schedule of all chain link fencing and gates indicating locations of all post and fabric types on the project.
3. Submit a complete welding plan for the cantilever slide gate frame

D. Samples: Prior to ordering the below listed materials, submit samples to the Owner’s Representative for approval. Samples shall be representative of designated items. Do not order materials until Owner’s Representative’s approval has been obtained. Delivered materials shall closely match the approved samples.

1. One square foot of each chain link fabric type.
2. One sample of each size of post tops

3. One 12-inch length of each size of pipe
4. One sample of each type of hardware and fitting

E. Construct a representative fence section sample with gate on-site for each size and type of chain link fence construction. Samples shall be constructed prior to the installation of all chain link fencing and as part of the proposed finish work to facilitate comparisons during construction. The samples shall demonstrate the typical installation of fence posts and footings, framework, vinyl coatings, hardware fittings and miscellaneous materials. The accepted sample, upon approval, shall be maintained as the standard of minimal quality for approval of all proposed chain link fence work required for the project. Unacceptable sample sections shall immediately be removed from the site.

PART 2 - PRODUCTS

2.1 PVC COATED FENCE FABRIC

A. Polyvinyl Chloride (PVC) Coated Fabric: Fence fabric shall be zinc coated in accordance with ASTM A392 Class-2 or ASTM A491. The color of the fabric shall be black and in accordance with ASTM F934.

B. Fabric shall be woven into a 2 in. mesh of 9 finished gauge (0.148 in.) galvanized wire with a minimum breaking strength of 1290 lb. in accordance with ASTM F 668, Class 2b. All fabric shall be knuckled at both selvages. Public side of fabric shall be installed in accordance with the Owner's direction.

2.2 CHAIN LINK FENCE POSTS, HARDWARE, AND FITTINGS- GENERAL

A. General Fence Framework Requirements:

1. Type II, Group IC round steel pipe (electric resistance welded), cold-formed as per ASTM F1043-00 Standard with minimum yield strength of 50,000 psi. The external zinc coating shall be Type B, zinc with polymer film, 0.90 oz./sq.ft., minimum zinc coating with a chromate conversion and a verifiable polymer film. The internal coating shall be Type B, zinc 0.90 oz./sq.ft. minimum or Type D, zinc pigmented, 91% nominal coating with 0.30 mils minimum thickness. Gate framework joints shall be welded and coated in accordance with Practice A780, employing zinc-rich paint.

2.3 END, CORNER AND PULL POST.

A. Galvanized steel, physical pipe dimensions and weights

1. Up to 12-foot fabric height: 2.875-inch OD pipe, 4.64-lbs. /lin. ft.
2. For basketball and tennis courts: 4.000-inch OD pipe, 6.56-lbs. /lin. ft.
3. For combo batting cage/bullpen and backstop: 4.000-inch OD pipe, 6.56-lbs. /lin. ft.
4. Maximum Spacing between all posts is 10'- 0" On Center.

2.4 LINE POSTS.

A. Galvanized steel, physical pipe dimension and weights as follows:

1. Up to 12-foot fabric height: 2.375-inch OD steel pipe, 3.12-lbs. /lin. ft.

2. For basketball and tennis courts: 2.875-inch OD pipe, 4.64-lbs. /lin. ft.
3. For combo batting cage/bullpen and backstop: 4.000-inch OD pipe, 6.56-lbs. /lin. ft.
4. Maximum Spacing between all posts is 10'- 0" On Center.

2.5 GATE POSTS.

A. Galvanized steel, single gate widths, physical pipe dimension and weights as follows:
1. Up to 6-feet: 2.875-inch OD pipe, 4.64-lbs./linear ft.
2. Over 6-feet to 13 feet: 4.0 inch OD pipe, 6.56-lbs./ linear ft.
3. Gate frames as per ASTM F 900-94.

2.6 RAILS (TOP, MIDDLE AND BOTTOM RAILS):

A. Galvanized steel, manufacturer's longest lengths joined by six inch (6") long sleeves, rail shall run continuously along top of fence. Bottom rail shall be joined at line posts with boulevard clamps. Minimum pipe sizes and weights as follows:
1. 1.660-inch OD pipe, 1.82-lbs. /lin. ft. minimum.
2. Top, Bottom, Middle and Intermediate rails are required for fencing adjacent to the sports court footprint.

2.7 COUPLINGS:

A. Expansion types, approximately 6-inch long, install one sleeve for each 500 foot run. Standard couplings are installed at each rail end to form one continuous top rail. City of Worcester Department of Public Works and Parks – WPRC DIVISION 24

2.8 ATTACHING DEVICES:

A. Provide fittings for attaching top rail securely to each gate corner pull and end post as noted on drawings.

2.9 SLEEVES:

A. Galvanized steel pipe not less than 6 inches long and with inside diameter not less than 1/2-inch greater than outside diameter of the post pipe. Provide steel plate closure welded to bottom of sleeve of width and length not less than 1-inch greater than outside diameter of sleeve.

2.10 POST BRACE ASSEMBLY:

A. Manufacturer's standard adjustable braces at end of gateposts and at both sides of corner and pull posts. Provide horizontal brace located at mid-height of fabric. Use same material as top rail for brace, and truss to line posts with 3/8-inch diameter galvanized steel truss rods and adjustable tightener.

2.11 POST TOPS:

A. Galvanized steel, weather-tight closure cap for each tubular post. Furnish caps with openings to permit passage of top rail.

2.12 TENSION BARS:

A. Galvanized steel, one piece lengths equal to full height of fabric, with minimum cross-section of 3/16 inch x 3/4 inch. Provide tension bar for each gate and end post, and two for each corner and pull post. Stretcher Bar Bands will be manufacturer's standard.

2.13 GATE CROSS-BRACING:

A. 3/8-inch diameter galvanized steel truss rods and adjustable tightener.

2.14 NON-SHRINK, NON-METALLIC GROUT:

A. Premixed, factory-packaged, non-corrosive, non-staining, nongaseous, exterior grout approved by the Engineer.

2.15 SLEEVES

A. Sleeves if required for fence shall be galvanized steel pipe conforming to ASTM F1043 sizing as required to accommodate posts.

2.16 POLYMER COATED FRAMEWORK

A. Shall meet the above-mentioned specification for materials.

B. The framework shall be subjected to a complete thermal stratification coating process (multi-stage, high-temperature, multi-layer) including, as a minimum, a six stage pretreatment/wash (with zinc phosphate), an electrostatic spray application of an epoxy base, and a separate electrostatic spray application of a polyester finish.

1. The material used for the base coat shall be a zinc-rich (gray color) thermosetting epoxy; the minimum thickness of the base coat shall be two (2) mils.
2. The material used for the finish coat shall be a thermosetting "no-mar" TGIC polyester powder; the minimum thickness of the finish coat shall be two (2) mils.

C. Standards

1. The stratification-coated pipe shall demonstrate the ability to endure a salt-spray resistance test in accordance with ASTM B117 without loss of adhesion for a minimum exposure time of 3,500 hours.
2. The coated pipe shall demonstrate the ability to withstand exposure in a weather-ometer apparatus for 1,000 hours without failure in accordance with ASTM D1499 and to show satisfactory adhesion when subjected to the crosshatch test, Method B, in ASTM D3359.
3. The polyester finish coat shall not crack, blister or split under normal use.

D. Painted framework and accessories are not acceptable, welded joints shall be top-coated to match frame color.

E. Color of the polymer coated framework and accessories shall be black and in accordance with ASTM F934.

2.17 CHAIN LINK FENCE GATES AND GATE FRAMES

A. Fabrication: Assemble gate frames by welding connections. Use same fabric as for fence, unless otherwise indicated. Install fabric with stretcher bars at edges, and fabric ties. Attach stretcher bars to gate frame at not more than 15 in. o.c. Attach hardware with rivets or by other means which will provide security against removal or breakage.

1. Gate Heights:

a. Heights for gates shall be in accordance with MSSHB 644.45.

B. Single and Double Swinging Gate and Hardware: Swing gates and hardware shall be manufactured to meet the requirements of ASTM F900. Unless indicated otherwise, and to meet ADA requirements, the minimum clear opening for all single gates (as measure with gate perpendicular to framework) shall be 36 inches.

1. Hinges. Industrial butt hinges, size and material as required for the gate size. Non-lift-off type, offset to permit 180 degree gate opening. Provide one pair of hinges for each leaf, gates eight feet and taller in nominal height shall have three hinges per leaf. Spot-weld to post and paint (non polymer coated), to prevent rotational movement.
2. Latch (for both single and double gates). Pressed steel, industrial series gate latch, straight fork type, provide latch catch for double gates, designed to permit operation from either side of gate, with padlock eye as integral part of latch catch. Provide two latch and catch for double gates. All gates shall be equipped with one gate stop.

2.18 CAPS

A. Posts shall have caps which shall be designed to exclude water from post. Caps shall have holes suitable for the through passage of the top rail where necessary.

2.19 FABRIC TIES:

A. Ties for fastening fabric to top, bottom, middle and brace rails shall be black “band it” ties, stainless steel vinyl coated or approved equal, spaced at 12” on center to form a secure connection.

2.20 GALVANIZED PAINT

A. Cold galvanized paint for field touch-up shall be one of the following:

Product	Manufacturer
GALVICON	GALVICON CORPORATION
ZINC SHIELD	STANLEY CHEMICAL DIVISION OF THE STANLEY WORKS

2.21 CONCRETE

A. Concrete shall be air-entrained type, conforming to Section 033001, CAST-IN-PLACE CONCRETE – SITEWORK

PART 3 - EXECUTION

3.1 INSTALLATION

A. Chain link fence installation shall conform to ASTM F 567, except as modified below.

B. Line posts shall be placed at not more than 10 ft. on center, or as indicated on Drawings.

C. Fence heights (measured from finish grade to top rail) length, and layout shall be as indicated on Drawings.

D. Install fabric on security side of fence. Wire fabric shall be attached to frame, and tightly stretched such that it is flat, in uniform tension with no bulges or warping of fence or gate after pulling force is released. Fabric ties shall be spaced at 12 in. on horizontal rails, braces, and posts. Seam of fabric tie shall be hammered flat to member to minimize hazard to person or clothing. Top and bottom of the fabric shall extend on half the height of the “diamond” beyond outer edge of top and bottom of the horizontal rail. The fabric shall also be one (1) inch maximum above finish grade. The fabric shall be tied in accordance with Item 1 below to all line posts, top, middle and bottom rails every six (6) “diamonds” as measured horizontally or vertically. Overlapping fence fabric sections shall overlap one full height of the “diamond” and be centered on the horizontal rail Top of fence shall approximately follow grade and shall have no abrupt changes in slope. Height of fence shall be constant.

1. All fabric, shall be fastened to all line posts and horizontal rails with fabric ties. All fabric ties shall be pulled tight and raw ends of steel bands shall be secured in buckle by folding ear tabs around steel bands as per manufacturer's recommended installation procedure. No sharp edges shall protrude from band-it buckles.
2. Fasteners: Install nuts for tension band and hardware bolts on side of fence opposite fabric side.
3. Bolts: Used in the construction of fence shall be thoroughly peened.

E. Stretcher Bars: Extend through fabric and secure to end, corner, pull and gate posts with bands or clips spaced not over 12 in. o.c.

3.2 GATES

A. Install gates plumb, level, and secure for full opening without interference.

B. Gate dimension is the center to center spacing of gate posts.

C. Gates shall work freely and shall have adequate clearance of the bottom. Adjust for smooth operation.

3.3 FOUNDATIONS

A. General: Unless otherwise indicated on the Drawings, footing diameter shall be four times the largest cross section of the post. The depth shall be as indicated on the Drawings.

B. Concrete shall be crowned at top to shed water.

C. Post hole footings shall be allowed to cured 72 hours prior to any additional work.

3.4 POSTS

A. Layout:
   1. End, corner and pull post: Provide at each termination and change in horizontal or vertical direction of 30 degrees or more.
   2. Line Posts: Space uniformly at maximum10 feet on center.

B. Concrete Set Posts for site enclosure fence: (Corner, End and Pull Posts) Drill holes (after final grading) in firm, undisturbed or compacted soil. Holes shall have a diameter equal to four times the diameter of the post, and depths approximately 6 in. deeper than post bottom. Excavate deeper as required for adequate support in soft and loose soils, and for posts with heavy lateral loads.
   1. Set post not less than 35 in. below surface when in firm, undisturbed soil.
   2. Place concrete around posts in a continuous pour, tamp for consolidation. Trowel finish tops of footings, and slope or dome to direct water away from posts, except at walks.
   3. Gate posts and hardware: Set keepers, stops, sleeves and other accessories into concrete.

C. Posts set in cast in place walls or perimeter curb at sports field: (Corner, End and Pull Posts) Core cast in place concrete to accept post per detail and fill with non-shrink grout to secure post.

3.5 BRACING AND FRAMING

A. Bracing: Install horizontal pipe brace at mid height for fences 6 ft. and over, on each side of corner posts and at gate, end, and pull posts. Firmly attach with proper fittings. Install diagonal tension rods at these points. Install braces so posts are plumb when diagonal rod is under proper tension.

B. Top Rail:
   1. Random length, averaging not less than 18 feet.
   2. Pressed steel sleeve joints, for rigid connections and expansion/contraction.

3.6 CHAIN LINK CANTILEVER SLIDE GATE FRAMING INSTALLATION

A. Install gateposts in accordance with manufacturer’s instructions.

B. Concrete set gateposts: Drill holes in firm, undisturbed or compacted soil. Holes shall have diameter 4 times greater than outside dimension of post, and depths approximately 6” (152 mm) deeper than post bottom.

C. Excavate deeper as required for adequate support in soft or loose soils, and for posts with heavy lateral loads. Set post bottom 36” (914 mm) below surface when in form, undisturbed soil. Place concrete around posts in continuous pour, tamp for consolidation. Trowel finish around post and slope to direct water away from posts. Check each post for vertical and top alignment and maintain in position during placement and finishing operations.

3.7 TOUCH UP

A. Following installation, scratches and marred spots in galvanized surfaces shall be power wire brushed and painted with a cold-applied galvanized paint at a rate of 2.0 oz. zinc per sq. ft. of surface.

B. Inspect all fencing following installation to check for proper tension, stability, structural integrity and gate function, and adjust, repair or replace as required to establish proper function prior to final review and acceptance.

END OF SECTION

Section 32 31 15
METAL FENCE AND GATE

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01, GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.2 DESCRIPTION OF WORK

A. Provide all equipment and materials, and do all work necessary to construct the metal fence(s) and gate(s) as indicated on the Drawings and as specified herein.

1.3 RELATED SECTIONS

A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that directly relate to work of this Section include, but are not limited to:

1. Section 033001, CAST-IN-PLACE CONCRETE - SITEWORK
2. Section 055001, METAL FABRICATIONS - SITEWORK.

1.4 REFERENCES

A. Comply with applicable requirements of the following standards. Where these standards conflict with other specified requirements, the most restrictive shall govern:

1. American Society for Testing and Materials (ASTM):

A 185 Steel Welded Wire fabric, Plain for Concrete Reinforcement

A653/A653M Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy Coated (Galvannealed) by the Hot-Dip Process.

ASTM B117 Practice for Operating Salt-Spray (Fog) Apparatus.

ASTM D523 Test Method for Specular Gloss.

ASTM D714 Test Method for Evaluating Degree of Blistering in Paint.

ASTM D822 Practice for Conducting Tests on Paint and Related Coatings and Materials using Filtered Open-Flame Carbon-Arc Light and Water Exposure Apparatus.

ASTM D1654 Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments.

ASTM D2244 Test Method for Calculation of Color Differences from Instrumentally Measured Color Coordinates.

ASTM D2794 Test Method for Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact).

ASTM D3359 Test Method for Measuring Adhesion by Tape Test.

A 36 Structural Steel

A 53 Pipe, Steel, Black and Hot-Dipped, Zinc-Coated Welded and Seamless

A 123 Zinc (Hot-Galvanized) Coatings on Products Fabricated from Rolled, Pressed and Forged Steel Shapes, Plates, Bars, and Strip

A 153 Zinc Coating (Hot-Dip) on Iron and Steel Hardware

A 385 High-Quality Zinc Coatings (Hot-Dip)

A 386 Zinc Coating (Hot-Dip) on Assembled Steel Products

A 501 Hot-Formed Welded and Seamless Carbon Steel Structural tubing

2. American Welding Society (AWS):

   D1.1 Structural Welding Code – Steel

3. Steel Structures Painting Council (SSPC):

   SP 6 Commercial Blast Cleaning

1.5 SUBMITTALS

A. Shop Drawings: Provide large scale shop drawings for fabrication, installation and erection of all parts of the work. Provide plans, elevations and details for all fences, railings, gates and guardrails in this section. These drawings shall show sizes and thicknesses of all members, types of materials, methods of connection and assembly, complete dimensions, clearances, anchorage, relationship to surrounding work by other trades, shop paint and protective coatings, and other pertinent details of fabrication and installation.

B. Sample Panels:

1. Submit samples of all fence materials to be furnished under this Section in a 2 ft. x 2 ft. fully assembled fence panel, unless otherwise requested by Architect.
2. Submit samples of all gate materials to be furnished under this Section in a 2 ft. x 2 ft. fully assembled gate, unless otherwise requested by Architect.
3. Each assembled section shall exhibit specified post, picket and rail components, hardware, fittings, hinges, post and picket top treatment, color and finish.
4. Architect will review submitted sample panels and, if not acceptable, reserve the right to request additional panels at no cost to the Owner. Contractor shall provide additional panels until Architect approves. Approved panels shall remain in Architect's possession, and become the standard for measuring acceptance of completed fence and gate installations.

C. Product Data: Submit manufacturer's printed product data, specifications, standard details, installation instructions, use limitations and recommendations for each material used. Provide certifications that materials and systems comply with specified requirements.

1. Fence and gate posts, and fittings.
2. Gates and hardware.

D. Qualification Data: For Installer.

E. Do not order materials or begin fabrication until Architect's approval of submittals has been obtained.

F. Field Measurements: Take all necessary field measurements before preparation of shop drawings and fabrication. Do not delay progress of the job. If field measurements are not possible prior to fabrication, allow for field cutting and fitting. Center fencing in locations shown on drawing and provide no greater than a 4” gap between adjacent buildings and other fixed elements unless otherwise noted on the drawings.

G. Initial Selection Samples: Submit samples showing complete range of colors, textures, and finishes available for each material used.

H. Verification Samples: Submit representative samples of each material that is to be exposed in the completed work. Show full color ranges and finish variations expected. Provide samples having minimum size of 144 sq. in.

I. Calculations: Provide professionally prepared calculations and certification of the performance of this work. Indicate how design requirements for loading and other performance criteria have been satisfied.

1.6 QUALITY ASSURANCE

A. The Contractor shall provide laborers and supervisors who are thoroughly familiar with the type of construction involved and materials and techniques specified.

1.7 SPECIAL WARRANTY

A. Provide manufacturer’s standard limited warranty that its ornamental metal fence and gate system is free from defects in material and workmanship including cracking, peeling, blistering and corroding for a period of 12 years from the date of substantial completion.

1.8 PRODUCT HANDLING AND STORAGE

A. Materials shall be carefully handled and stored under cover in manner to prevent deformation and damage to the materials and to shop finishes, and to prevent rusting and the accumulation of foreign matter on the metal work. All such work shall be repaired and cleaned before erection.

1.9 GENERAL REQUIREMENTS:

A. The Contractor shall verify all measurements and shall take all field measurements necessary before fabrication. Welding to or on structural steel shall be in accordance with AWS D1.1/D1.1M. Items specified to be galvanized, when practicable and not indicated otherwise, shall be hot-dip galvanized after fabrication. Galvanizing shall be in accordance with ASTM A 123/A 123M, ASTM A 653/A 653M, or ASTM A 924/A 924M, as applicable. Exposed fastenings shall be compatible materials, shall generally match in color and finish, and shall harmonize with the material to which fastenings are applied. Materials and parts necessary to complete each item, even though such work is not definitely shown or specified, shall be included. Poor matching of holes for fasteners shall be cause for rejection. Fastenings shall be concealed where practicable. Thickness of metal and details

of assembly and supports shall provide strength and stiffness. Joints exposed to the weather shall be formed to exclude water.

1.10 QUALITY ASSURANCE

A. Source: For each material type required for the work of this section, provide primary materials which are the product of one manufacturer. Provide secondary or accessory materials which are acceptable to the manufacturers of the primary materials.

B. Engineering: Provide services of Professional Engineer, registered in the Commonwealth of Massachusetts, to design and certify that work of this Section meets or exceeds performance requirements specified.

1.11 PERFORMANCE REQUIREMENTS

A. General: Provide installed fence and gate assemblies complying with the following structural performances, unless otherwise specified:

1. Live loads shall not be less than the minimum required by applicable building codes.
2. Design shall incorporate safety factors as required by the applicable building codes.
3. Design and construction shall be as such to assure that under the required design live loads that there shall be no failure of any member, deflection of not more than L/240 of length of any member, and without permanent deformation of any member or fastener.

1.12 ANCHORAGE

A. Anchorage shall be provided as shown and where necessary for fastening fences and gates securely in place. All posts to be secured per manufacturers specifications.

1.13 DISSIMILAR MATERIALS

A. Where dissimilar metals are in contact, or where aluminum is in contact with concrete, mortar, masonry, wet or pressure-treated wood, or absorptive materials subject to wetting, the surfaces shall be protected with a coat of bituminous paint or asphalt varnish.

1.14 QUALITY ASSURANCE

A. Fabricator qualifications

1. Fabricator shall have at least five years of fabricating similar type product in similar climatic conditions.
2. Provide evidence of similar work.

B. Installer qualifications.

1. Installer shall possess at least five years experience installing similar work under similar conditions.
2. Provide evidence of such experience.

1.15 DELIVERY, STORAGE AND HANDLING

A. Delivery and Acceptance Requirements:

1. Do not deliver items to the site, until all specified submittals have been submitted to, and approved by, the Architect.
2. Deliver materials in labeled, protective packages, when and as required.

B. Storage and Handling Requirements:

1. Store and handle in strict compliance with manufacturer's instructions.
   a. Carefully store materials to avoid overloading any building component or structure.
   b. Do not unpack material until it is to be set, unless un-packing is required for inspection by the Architect.
2. Protect factory finished materials from damage due to moisture, direct sunlight, excessive temperatures, surface contamination, corrosion and damage from construction operations and other causes.

PART 2 - PRODUCTS

2.1 LOUVERED SCREEN FENCE

A. Fence located at eastern courtyards and utility areas shall be as follows:

1. Ametco Shadow 100 Louvered Fence Panel, Electro-forged welded steel fencing. Design horizontal 1-31/32" x 1/16" formed main bar, 5/32" round cross bar forming a 1-13/16" x 5-7/32" mesh. Galvanized to ASTM 123 weighs 3.50 lbs. per Sq.Ft. flat horizontal, round vertical bars.
   a. View blocking 100%
   b. Hot-dipped galvanized finish
   c. Height : Varies; As indicated on Drawings.
   d. Installation: Base plates fastened to CIP Concrete walls or on concrete slabs in locations as indicated on Drawings. Submit shop drawing for approval.
   e. Posts:
      1) Size: 2" x 2" square posts
      2) Length: As indicated.
      3) Cap: square caps with universal brackets

2.2 DECORATIVE / SECURITY GATE

A. At Courtyard

1. Infill Panel: Ametco Shadow 100 Fence System, electro-forged welded steel fencing. consisting of modular open grille fencing panels fabricated by welding flat steel bars and rods, supported by steel posts and gates and gate hardware; manufactured by Ametco® Manufacturing Corporation, P.O. Box 1210, Willoughby, Ohio 44096; Telephone: 800-362-1360; www.Ametco.com, or approved equal.

2. Gate at NGrid Utility Area: Double Swing gate with tube frame, padlock slidebolt and padlock cane bolt. Provided by Ametco Shadow 100 by Ametco Manufacturing or approved equal. Dimensions as shown on Drawings.

2.3 COATINGS

A. Zinc coating:
1. The wire meshes is coated with 0.5 oz./sq.ft. (150 g/m2) zinc in conforms to ASTM A
2. The fence posts, the swing gate frame and the posts are zinc coated (galvalume process) with a minimum of 0.9 oz/sq.ft. (275 g/m2) as per ASTM A653 G90.

B. Polyester surface coating Polyester coating to be minimum 4 mils applied by an electrostatic method. Coating shall cover all surfaces of the wire and post sections. Coating shall be capable of withstanding the following tests:
1. Mechanical adhesion test as per ASTMD 3359 (1990) - Method B.
2. Shock resistance tests as per ASTM D 2794 (1990).
3. Salt spray testing with a min. of 1,000 hrs without red rust appearance, as per ASTM B 117 (1990).
4. Humidity resistance in a weather meter chamber as per ASTM D 2247 (1988).
5. Exposure to ultraviolet light with exposure of 1000 hours using apparatus Type E and 63°C as per ASTM D1499
6. Color TBD

2.4 KEYING AND LOCK CYLINDERS

A. Provide interchangeable core cylinders, removable by use of special key, for all locking devices on this project. Provide temporary cores during construction. Remove and replace temporary cores when directed

B. Comply with Owner's instructions for keying of Project. Provide grandmaster key system unless otherwise indicated.

C. Metals: Provide cylinders and keys from stainless steel, brass, or nickel silver.

D. Provide three keys for each lock, five master keys, and five grand master keys. Provide one blank key for each lock.

E. Provide three additional cores, keyed only into this system.

2.5 SETTING MATERIAL

A. Comply with Section 033301, CAST-IN-PLACE CONCRETE – SITEWORK.

2.6 FASTENERS AND ANCHORS

A. Provide all anchors, bolts, sockets, sleeves, and other parts required for securing each item of work of this Section to the construction. Furnish required inserts and sleeves for installation in concrete under Section 033001, CAST-IN-PLACE CONCRETE - SITEWORK.

B. Exposed fastenings shall be of the same material and finish as the metal to which applied, unless otherwise noted.

C. Welding rods shall conform to AWS Standards and the recommendation of the welding rod manufacturer. Welding of steel shall conform to AWS D1.1.

2.7 GROUT

A. Epoxy Grout: Provide non-shrink, non-metallic, non-corrosive epoxy grout conforming to the following requirements:

1. Grout shall be manufactured specifically for use in supporting heavy loads.
2. Shrinkage at 28 days: None (0.00 shrinkage when tested in accordance with ASTMC827modified procedure) with a minimum effective bearing area (EBA) of 95 percent coverage of the tested base plate.
3. Compressive strength, minimum: 10,000 psi at seven days, when tested in accordance with ASTM C579.
4. Initial setting time: Approximately one hour at 70 degrees F.
5. Provide flowable consistency as necessary for the particular application.
6. Epoxy grouts which are volatile and which give off noxious fumes are not acceptable.

2.8 FINISHES

A. Galvanizing: Hot-dip galvanize items as indicated to comply with applicable standard listed below:

1. ASTM A 123/A 123M, for galvanizing steel and iron products.
2. ASTM A 153/A 153M, for galvanizing steel and iron hardware.

B. Preparation for Shop Priming: Prepare uncoated ferrous-metal surfaces to comply with minimum requirements indicated below for SSPC surface preparation specifications and environmental exposure conditions of installed metal fabrications:

1. Exteriors and Items Indicated to Receive Zinc-Rich Primer: SSPC-SP 6/NACE No. 3, "Commercial Blast Cleaning."

2.9 HOT DIP GALVANIZING

A. Hot-Dip Galvanizing: Provide coating for iron and steel fabrications applied by the hot-dip process, Duragalv® by Duncan Galvanizing, or approved equal. Comply with ASTM A 123 for fabricated products and ASTM A 153 for hardware. Provide thickness of galvanizing specified in referenced standards. The galvanizing bath shall contain special high grade zinc, nickel, and other earthly materials.

B. Galvanizing shall exhibit a rugosity (smoothness) not greater than 4 rug (16-20 microns of variation) when measured by a profilometer over a 1 inch straight line on the surface of architectural and structural elements that are less than 24 pounds per running foot. Profilometer shall be capable of operating in 1 micron increments.

2.10 ELECTROLYTIC SEPARATION

A. Coating for electrolytic separation between steel and concrete and grout shall be a high- build coal tar epoxy providing one coat protection for steel and concrete in a variety of chemical, immersion and underground conditions, manufactured by Tnemec Company, Inc., 6800 Corporate drive, Kansas City, MO 64120-1372; Tel. 816-483-3400; Kop-Coat Inc, 436 Seventh Avenue, Pittsburgh, PA 15219-1818; 1/412/227-2700, parent company RPM, International 2628 Pearl Road - P.O. Box 777 - Medina, Ohio 44258; Phone: 330.273.5090 - Fax: 330.225.8743; Carboline Company, 2150 Schuetz Road, St. Louis, MO 63146; Phone: 800-848-4645 or 314-644-1000; FAX: 314-644-4617, or approved equal.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify areas to receive fencing are completed to final grades and elevations.

B. Ensure property lines and legal boundaries of work are clearly established.

3.2 PREPARATION

A. Prior to fabrication, field verify required dimensions.

B. Base plates shall provide minimum 2” clear from edge of concrete wall or slab from edge of base plate.

3.3 INSTALLATION

A. Install fencing in accordance with manufacturer's installation instructions and approved shop drawings.

B. Install fence posts plumb and level in concrete and grouting solid. Temporarily brace fence posts with 2 by 4 wood supports until set.

C. Do not installed bent, bowed, or otherwise damaged panels. Remove damaged components from site and replace.

D. Secure fence panels with standard stainless steel bolts to fence posts prior to setting posts in footings.

E. Gates:

1. Install gates and adjust hardware for smooth operation.
2. Provide concrete center foundation depth and drop rod retainers at center of double swinging gate openings.
3. After installation, test gate. Open and close a minimum of five times. Correct deficiencies and adjust.

F. Touch-up damaged finish with paint supplied by manufacturer and matching original coating.

3.4 FABRICATION AND WORKMANSHIP

A. Metal surfaces shall be clean and free from mill scale, flake, rust and rust pitting; well-formed and finished to shape and size, true to details with straight, sharp lines and angles and smooth surfaces. Curved work shall be to true radii. Exposed sheared edges shall be eased.

B. Weld all permanent connections unless otherwise indicated. Weld shall be continuous on all exposed surfaces and where required for strength on concealed surfaces. Exposed welds shall be ground flush and smooth, with voids filled with metallic filling compound. Tack-welding will not be permitted unless specifically called for. Do not use screws or bolts where they can be avoided. Where used, heads shall be countersunk, screwed up tight and threads nicked to prevent loosening.

C. Fastenings shall be concealed where practical. Thickness of metal and details of assembly and supports shall provide required strength and stiffness. Joints exposed to weather shall be formed to exclude water.

D. Do all cutting, punching, drilling, and tapping required for attachment of hardware and of work of other Sections where so indicated or where directions for same are given prior to, or with approval of, shop drawings.

E. Live loads: Refer to Paragraph 1.121 Factor of safety shall not be less than 2-1/2 to 1.

3.5 COATINGS

A. Galvanizing:

1. Ferrous metal under this Section for exterior use shall be hot-dip galvanized, including all bolts, nuts, washers, and other related ferrous metal items used therewith.
2. Hot-dip galvanizing process shall comply with ASTM A 123, A 153, A 385, and A 386, as applicable. After galvanizing, processed items shall be straightened to remove all warpage and distortion caused by the process.
3. Furnish to the Contractor, with copy to Architect, a certified statement that galvanizing complies fully with this Specification.

3.6 INSTALLATION - GENERAL

A. Materials shall be carefully handled and stored under cover in manner to prevent deformation and damage to the materials and to shop finishes, and to prevent rusting and the accumulation of foreign matter on the metal work. All such work shall be repaired and cleaned prior to erection.

B. Work shall be erected square, plumb, and true, accurately fitted, and with tight joints and intersections. All anchors, inserts and other members to be set into concrete or masonry shall be furnished loose by this trade to be built-into concrete and masonry by those trades as the work progresses. Later cutting or drilling shall be avoided wherever possible.

C. Metal work shall be rigidly braced and secured to surrounding construction, and shall be tight and free of rattle, vibration, or noticeable deflection after installation.

D. Where members, other than expansion bolts or inserts, are fastened into concrete, set such members in proprietary-type expanding grout manufactured specifically for such purpose, used strictly in accordance with manufacturer's directions. Holes to receive members shall be formed with galvanized sheet metal sleeves, expanded polystyrene foam, or other approved method to provide at least 1/2 in. clearance around entire perimeter. At exposed applications, hold expanding grout back 1/2 in. from finish surface and fill voids with Portland cement grout to match color and texture of surrounding concrete surface.

E. Electrolytic Isolation: Where dissimilar metals are to come into contact with one another, isolate by application of a heavy coating of bituminous paint on contact surfaces in addition to shop coat specified above. Do not permit the bituminous paint in any way to remain on surfaces to be exposed or to receive sealant.

3.7 ADJUSTING

A. Gate: Adjust gate to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.

B. Lubricate hardware and other moving parts.

3.8 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's personnel to adjust, operate, and maintain gates.

3.9 ACCESSORIES

A. Install post caps and other accessories to complete fence.

3.10 CLEANING

A. Clean up debris and unused material, and remove from site.

END OF SECTION

SECTION 32 32 23
SEGMENTAL RETAINING WALLS

PART 1 – GENERAL

1.1 DESCRIPTION

A. Work includes designing, furnishing and installing precast modular concrete retaining walls to the lines and grades designated on the Contract Drawings and as directed by the Architect/Engineer. Also included is furnishing and installing appurtenant materials required for construction of the retaining wall as shown on the Contract Drawings.

1.2 REFERENCE STANDARDS

A. Segmental Retaining Wall Units
   1. ASTM C 140 - Sampling and Testing Concrete Masonry Units
   2. ACTM C 90 - Hollow Load-Bearing Concrete Masonry Units
   3. ASTM C 145 - Solid Load-Bearing Concrete Masonry Units

B. Geosynthetic Reinforcement
   1. ASTM D 4595 - Tensile Properties of Geotextiles by the Wide-Width Strip Method.
   2. ASTM D 5262 - Test Method for Evaluating the Unconfined Creep Behavior of Geosynthetics
   3. GRI: GG1 - Single Rib Geogrid Tensile Strength
   4. GRI: GG5 - Geogrid Pullout

C. Soils
   1. ASTM D 698 – Moisture-Density Relationship for Soils, Standard Method
   2. ASTM D 422 - Gradation of Soils
   3. ASTM 4318 - Atterberg Limits of Soil

D. Drainage Pipe
   1. ASTM D1248 - Specification for Corrugated Plastic Pipe

E. Where specifications and reference documents conflict, the Architect/Engineer shall make the final determination of applicable document.

F. Reference is made to the Global Stability Analysis prepared by the project's Geotechnical Engineer.

G. Reference is made to the Geotechnical Report Appendices A-1 thru A- 3.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

B. Material Submittals: The Contractor shall submit manufacturers' certifications two weeks prior to start of work stating that the units and geosynthetic reinforcement meet the requirements of Section 2 of this specification.

C. Delegated Design Submittal: All segmental retaining walls for this project shall be furnished by the Contractor as a delegated design. The Contractor shall submit two sets of detailed design calculations and construction drawings for approval at least three weeks prior to the beginning of wall construction. All calculations and drawings shall be prepared and sealed by a professional Civil Engineer experienced in wall design and licensed in the state of Massachusetts. Segmental retaining wall design shall incorporate the recommendations in the global stability analysis prepared by the project's Geotechnical Engineer, including minimum bury depth of base of wall.

D. Provide 3 samples of different face and color. Provide a mock-up sample on site (wall only) 4 feet wide x 5 feet tall for review and approval.

1.4 DELIVERY, STORAGE AND, HANDLING

A. Contractor shall check materials upon delivery to assure that specified type and grade of materials have been received and proper color and texture of units have been received.

B. Contractor shall prevent excessive mud, wet concrete, epoxies, and like materials which may affix themselves, from coming in contact with materials.

C. Contractor shall store and handle materials in accordance with manufacturer's recommendations.

D. Contractor shall protect materials from damage. Damaged materials shall not be incorporated into the retaining wall.

PART 2 – MATERIALS

2.1 SEGMENTAL RETAINING WALL UNITS

A. Units shall be machine formed, Portland Cement concrete blocks specifically designed for retaining wall applications. Modular precast concrete units shall be Unilock U-Clara system, Belgard Diamond Pro PS, or Keystone Compac.

B. Color of units shall be selected by the Owner.

C. Finish of units shall be smooth, flat, straight face.

D. Unit faces shall be of straight geometry.

E. Units shall be manufactured in accordance with ASTM C 90, C 140, and C 145, as applicable.

F. Units shall be solid through the full depth of the unit.

G. Units shall be no larger than the following dimensions: 8 inches tall, 18 inches wide, and 12 inches deep.

H. Units shall be capable of being erected with the horizontal gap between adjacent units not exceeding 1/8 inch.

I. For any corners shown on the construction plans, units shall be capable of providing overlap of units on each successive course so that walls meeting at corner are interlocked and continuous. Units that require corners to be mitered shall not be allowed.

J. Units shall be capable of providing a split face, textured surface for all vertical surfaces that will be exposed after completion of wall, including any exposed sides and backs of units.

K. Units shall be sound and free of cracks or other defects that would interfere with the proper placing of the unit or significantly impair the strength or permanence of the structure. Cracking or excessive chipping is grounds for rejection. Units showing cracks longer than 1/2" shall not be used within the wall. Units showing chips shall not be used within the wall.

L. Concrete used to manufacture units shall have a minimum 28-day compressive strength of 3,000 psi and a maximum moisture absorption rate, by weight, of 8% as determined in accordance with ASTM C 140. Concrete used to manufacture units shall be salt resistant.

M. Units' shall be interlocking and provide a vertical wall or a near vertical wall with maximum setback of 1 horizontally in 16 vertically.

2.2 SEGMENTAL RETAINING WALL UNIT CONNECTION PINS

A. Units shall be interlocked with connection pins or other structurally acceptable methods. The pins shall consist of glass-reinforced nylon made for the expressed use with the units supplied.

2.3 GEOSYNTHETIC REINFORCEMENT

A. When required, geosynthetic reinforcement shall consist of geogrids or geotextiles manufactured as a soil reinforcement element. The manufacturers/suppliers of the geosynthetic reinforcement shall have demonstrated construction of similar size and types of segmental retaining walls on previous projects.

B. The type, strength, and placement location of the reinforcing geosynthetic shall be as determined by the Contractor’s Civil Engineer, as shown on the approved shop drawings.

2.4 LEVELING PAD

A. Material for leveling pad shall consist of compacted gravel and shall be a minimum of 6 inches in depth. Lean concrete with a strength of 200-300 psi and three inches thick maximum may also be used as a leveling pad material. The leveling pad should extend laterally at least a distance of 6 inches from the toe and heel of the lowermost unit.

2.5 DRAINAGE AGGREGATE

A. Drainage aggregate shall be angular, clean stone or granular fill meeting the following gradation of ¾-inch crushed stone as defined in Section 31 20 00 Earth Moving.

2.6 DRAINAGE PIPE

A. The drainage collection pipe shall be a perforated or slotted HDPE pipe, as specified in Section 33 40 00 Storm Drainage Utilities.

PART 3 – EXECUTION

3.1 DESIGN

A. The design provided by the Contractor and prepared by the manufacturer shall consider the internal and local stability of the soil mass and shall be prepared in accordance with acceptable engineering practice, specifications, and applicable code requirements. The

design shall consider all loading conditions, including live loads of vehicles, guardrail, and temporary loading imposed during construction. Geotechnical investigations shall be made by the wall designer and the wall system shall be designed for a total settlement not to exceed one inch. Segmental retaining wall design shall incorporate the recommendations in the global stability analysis prepared by the project's Geotechnical Engineer, including minimum bury depth of base of wall.

3.2 EXCAVATION

A. Contractor shall excavate to the lines and grades shown on the Contract Drawings. Contractor shall take precautions to minimize over-excavation. Over-excavation shall be filled with compacted gravel at the Contractor's expense.

B. Contractor shall verify location of existing structures and utilities prior to excavation. Contractor shall ensure all surrounding structures and surfaces are protected from the effects of wall excavation. Excavation support, if required, is the responsibility of the Contractor.

3.3 FOUNDATION PREPARATION

A. Following the excavation, the foundation soil shall be examined by the wall designer to ensure actual foundation soil strength meets or exceeds the assumed design bearing strength. Soils not meeting the required strength shall be removed and replaced with gravel, as directed by the Engineer.

B. Foundation soil shall be proofrolled and compacted to 95% standard Proctor density and inspected by the Engineer prior to placement of leveling pad materials.

3.4 LEVELING PAD CONSTRUCTION

A. Leveling pad shall be placed and compacted as shown on the approved shop drawings.

3.5 MODULAR PRECAST CONCRETE UNIT INSTALLATION

A. All units shall be installed at the proper elevation and orientation as shown on the wall elevations and details on the Contract Drawings, shop drawings, and as directed by the Engineer. The units shall be installed in accordance with the manufacturer's recommendations.

B. First course of units shall be placed on the leveling pad. The units shall be leveled side-to-side, front-to-rear and with adjacent units, and aligned to ensure complete contact with the leveling pad. The first course is the most important to ensure accurate and acceptable results. No gaps shall be left between the front of adjacent units. Alignment shall be maintained by means of a string line or offset from baseline to the back of the units.

C. Clean all excess debris from top of units and install next course.

D. Layout of corners shall be installed in accordance with the shop drawings and in accordance with manufacturer's installation guidelines. Walls meeting at corners shall be interlocked by overlapping successive courses.

E. Repeat procedures to extent of wall height.

3.6 GEOSYNTHETIC REINFORCEMENT PLACEMENT

A. If required, all geosynthetic reinforcement shall be installed at the proper elevation and orientation as shown on the shop drawings and as directed by the Engineer.

B. At the elevations shown on the shop drawings, the geosynthetic reinforcement shall be laid horizontally on compacted gravel and on top of the concrete units. Embedment of the geosynthetic in the units shall be consistent with manufacturer's recommendations. Correct orientation of the geosynthetic reinforcement shall be verified by the Contractor to be in accordance with the geosynthetic manufacturer's recommendations. The highest strength direction of the geosynthetic must be perpendicular to the wall face.

C. Geosynthetic reinforcement layers shall be one continuous piece for their entire embedment length. Overlap of the geosynthetic in the design strength direction (perpendicular to the wall face) shall not be permitted.

D. Tracked construction equipment shall not be operated directly on the geosynthetic reinforcement. A minimum of 6 inches of backfill is required prior to operation of tracked vehicles over the geosynthetic. Turning should be kept to a minimum. Rubber-tired equipment may pass over the geosynthetic reinforcement at slow speeds (less than 5 mph).

E. The geosynthetic reinforcement shall be in tension and free of wrinkles prior to placement of soil fill. The nominal tension shall be applied to the reinforcement and secured in place with staples, stakes or by hand tensioning until reinforcement is covered by six inches of fill.

3.7 DRAINAGE MATERIALS

A. Drainage aggregate shall be installed to the line, grades, and sections shown on the shop drawings. Drainage fill shall be placed to the minimum thickness shown on the Contract Drawings between and behind units.

B. Drainage collection pipes shall be installed to maintain gravity flow of water outside the reinforced soil zone, as indicated on the Contract Drawings.

3.8 BACKFILL PLACEMENT

A. The gravel backfill shall be placed as shown in the construction plans in the maximum compacted lift thickness of 10 inches and shall be compacted to a minimum of 95% of standard Proctor density (ASTM D 698) at a moisture content within 2% of optimum. The backfill shall be placed and spread in such a manner as to eliminate wrinkles or movement of the geosynthetic reinforcement and the units.

B. Only hand-operated compaction equipment shall be allowed within 3 feet of the front of the wall face. Compaction within the 3 feet behind the wall face shall be achieved by at least three (4) passes of a lightweight mechanical tamper, plate, or roller.

C. At the end of each day's operation, the Contractor shall slope the last level of backfill away from the wall facing to direct water runoff away from the wall face.

D. At completion of wall construction, backfill shall be placed level with final top of wall elevation. If final grading, paving, landscaping, and/or storm drainage installation adjacent to the wall is not placed immediately after wall completion, temporary surface drainage shall be provided to ensure water runoff is not directed at the wall nor allowed to collect or pond behind the wall until final construction adjacent to the wall is completed.

3.9 WALL CAPS

A. Caps shall be properly aligned and installed along the top of the wall.

B. Caps shall overhang the top course of units by 3/4 to 1 inch. Slight variation in overhang is allowed to correct alignment at the top of the wall.

3.10 CONSTRUCTION ADJACENT TO COMPLETED WALL

A. The Contractor is responsible for ensuring that construction adjacent to the wall does not disturb the wall or place temporary construction loads on the wall that exceed design loads, including loads such as water pressure, temporary grades, or equipment loading. Heavy equipment shall be kept a minimum of three feet behind the back of the wall face. Care should be taken by the Contractor to ensure water runoff is directed away from the wall structure until final grading and surface drainage collection systems are completed.

End of Section

Section 32 32 53

STONE RETAINING WALLS

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01, GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.2 DESCRIPTION OF WORK

A. Provide all equipment and materials, and do all work necessary to salvage, clean and rebuild existing stone wall as shown on civil drawings and construct the new wall with stone veneer on concrete stem walls, as indicated on the Drawings and as specified herein.

1.3 RELATED SECTIONS

A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that directly relate to work of this Section include, but are not limited to:

1. Section 03 30 01, CAST-IN-PLACE CONCRETE - SITEWORK.
2. Section 31 20 00, EARTH MOVING

1.4 REFERENCES

A. Comply with applicable requirements of the following standards. Where these standards conflict with other specified requirements, the most restrictive requirement shall govern.

1. American Institute of Steel Construction (AISC):

Specification	Specification for the Design, Fabrication and Erection of Structural Steel for Buildings

2. American Society for Testing and Materials

(ASTM): A 36	Structural Steel
C 144	Aggregate for Masonry Mortar
C 150	Portland Cement
C 207	Hydrated Lime for Masonry Purposes
C 270	Mortar for Unit Masonry
C 616	Sandstone Building Stone

D 1752	Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
E 699	Criteria for Evaluation of Agencies Involved in Testing, Quality Assurance, and Evaluating Building Components in Accordance with Test Methods Promulgated by ASTM Committee E-6

1.5 SUBMITTALS

A. Samples: Submit representative samples of product to be furnished under this Section to Architect for selection and approval, as follows. Delivered materials shall closely match the approved samples. Samples shall be provided for the rebuilt and new walls and shall match color, texture and finish between the two wall types.

1. Stone Facing for new wall: Sufficient samples to show the full range of color, texture, and finish of stone proposed for use to match existing salvaged stone for wall to be re-built along Highland Ave. Minimum three samples of existing stone that are representative of the entire body of salvaged stone.
2. Stone Veneer Accessories: Duplicate samples of cramps, anchors, dowels, and other accessories as may be requested by Architect. See civil drawings C 10.5 for 'Stone Masonry Wall' construction detail.
3. Stone cap.
4. Mortar color.
5. Cap grout color

B. Manufacturer's Product Data: Manufacturer's product data shall be submitted for the following items which apply to both new and re-built walls:
1. Grout materials, including additives
2. Mortar coloring additive
3. Mortar materials, including additives

C. Shop Drawings for new and re-built walls: Representative layout drawings of stone pieces specified herein shall be submitted. Drawings shall indicate anchorage system, including anchors, cramps, dowels, etc., complete stone sizes, shelf depth, layout, finishes, arrangement and other necessary details for reception of other work.

1. Drawings shall indicate locations of inserts for stone anchors and supports which are to be built into concrete and masonry, and locations and dimensions of cut-outs, holes, openings, and other provisions required for the work of other trades.
2. Shop drawings shall indicate the setting number of each piece and each piece shall bear the corresponding number in a non-staining paint.

D. Contractor's Review: Before commencing work, submit written statement signed by the Contractor stating that the Contract Documents have been reviewed with a qualified representative of the stone supplier and mason, and that he/she is in agreement that the selected materials and construction are proper, compatible with adjacent materials, and adequate for the application shown.

1.6 SAMPLE INSTALLATION

A. Install in specific location directed by Architect at least one sample wall of each type (reconstruction Highland Street wall, W1 and new wall to match along Highland St, W2)

installation conforming to typical project construction. Sample installation shall each be approximately 30 sq. ft. in area, located as directed by Architect, and shall show the proposed stone type, color, and finish, cap stone, grout joint, joint sealing and other pertinent details of installation.

B. Replace sample installations as many times as necessary until Architect's approval of the installation has been obtained. Upon Architect's approval, construct all subsequent stone veneer work to conform to approved sample installation.

1.7 COORDINATION

A. The work of this Section shall be coordinated with that of other trades affecting, or affected by, this work, as necessary to assure the steady progress of the work under the Contract.

B. Do all cutting and drilling to accommodate the work of others as may be reasonably implied from the Drawings and Specifications, or required for the proper completion of the Work.

1.8 DELIVERY, HANDLING, AND STORAGE

A. New Stone and added stone shall be carefully packed and banded by the supplier for shipment. Following shipping stone shall be stored on wood skids or pallets, covered with non-staining, waterproof membrane and protected from the weather. Skids shall be placed and stacked in such a manner as to evenly distribute the weight of the stone materials and to prevent breakage, cracking, and damage to stone pieces. Stone materials shall be stored in such a manner as to allow air to circulate around the stone material. Stone shall not be permitted to be in direct contact with the ground any time during storage.

B. Existing wall stone shall be carefully removed, cleaned and salvaged in a manner to prevent chipping, breakage, soiling, or other damage. Pinch or wrecking bars shall not be used without protecting edges of stone with wood or other rigid materials. Stone units shall be lifted with wide-belt type slings wherever possible; wire rope or ropes containing tar or other substances which might cause staining or damage to stone finish shall not be used.

C. New stone shall be carefully handled to prevent chipping, breakage, soiling, or other damage. Pinch or wrecking bars shall not be used without protecting edges of stone with wood or other rigid materials. Stone units shall be lifted with wide-belt type slings wherever possible; wire rope or ropes containing tar or other substances which might cause staining or damage to stone finish shall not be used.

D. Stone damaged in any manner (salvaged or new) will be rejected and shall be replaced with new materials at no additional cost to the Owner.

E. Store setting materials on raised platforms or slabs, under watertight covers or indoors. Protect metal angles, anchors, cramps, dowels, etc. from the elements. Immediately before placing, remove all loose dirt and other foreign materials.

1.9 PROTECTION OF FINISHED SURFACES

A. Finished surfaces adjacent to the stone work shall be adequately protected from

soiling, staining, and other damage.

1.10 QUALITY ASSURANCE

A. Stone shall be supplied by a source approved by the Architect.

B. Stone shall be standard grade, free of cracks, seams, starts, or other defects which may impair its strength, durability, or appearance. Exposed surfaces shall be free from spots, spalls, chips, stains, discoloration, or other defects which would affect its appearance. Color, texture, and finish shall be within the range of samples approved by the Architect.

1.11 SINGLE SOURCE RESPONSIBILITY

A. Single Source Responsibility for Stone Wall Systems: Engage qualified installer for fieldstone systems to assume undivided responsibility for work of this section including design, engineering, fabrication and installation of stone veneer system to comply with following conditions and requirements:

1. Information on Drawings and in Specifications establishes requirements for both aesthetic effects and performance of fieldstone systems. Aesthetic effects relative to formal characteristics are indicated by dimensions, arrangement, alignment and profiles of components and assemblies as they relate to sight lines and relationships to one another and to adjoining work. Performance is indicated by criteria subject to verification by either preconstruction or field test, if applicable, or by in-service experience.
2. Do not modify intended aesthetic effects, as judged solely by Architect, except with Architect's approval and only to extent exclusively needed to comply with performance requirements. Where modifications are proposed, submit comprehensive explanatory data to Architect for review.
3. Engage qualified licensed professional engineer to prepare or supervise preparation of data for fieldstone systems which includes drawings, development of testing program, interpretation of test results and comprehensive engineering analysis evidencing system's compliance with performance and other requirements.

1.12 TESTING LABORATORY QUALIFICATIONS

A. To qualify for acceptance, an independent testing laboratory must demonstrate to Architect's satisfaction, based on evaluation of laboratory-submitted criteria conforming with ASTM E 699, that it has experience and capability to conduct satisfactorily testing indicated without delaying progress of Work.

1.13 PRECONSTRUCTION STONE TESTING

A. Engage a qualified independent testing agency to perform preconstruction testing indicated below:

1. Retesting of materials that fail to meet specified requirements shall be done at Contractor's expense.
2. Furnish test specimens that are representative of materials proposed for incorporation into the Work.
3. Physical Property Tests: For each stone variety proposed for use on Project,

tested for compliance with physical property requirements, other than abrasion resistance, according to referenced ASTM standards.

4. Flexural Strength Tests: For each stone variety, thickness, orientation of cut, and finish, proposed for use on Project, tested according to ASTM C 880 >, in both wet and dry conditions.
5. Anchorage Tests: For each stone variety, orientation of cut, finish, and anchor type proposed for use on Project, tested according to ASTM C 1354
6. Anchoring System Mockup Tests: For performance of stone anchoring system, evaluated for compliance with requirements by mockup testing per ASTM C 1201, Procedure B, with a maximum test load equal to 3 times the design load.
7. Contractor is required to build test mockups of representative portion of dimension stone cladding system corresponding to area indicated on Drawings. Build test mockups at testing agency's facilities from same materials proposed for Project, using installers who will perform same tasks for Project.
8. Testing agency will report test results in writing to Architect and Contractor.

1.14 PROJECT CONDITIONS

A. Protect, cover and wrap with plastic finished materials which might be damaged during construction. Provide additional protection for finished surfaces adjacent to stonework during cleaning work. Lift with wide belt type slings where possible. Do not use wire rope or ropes containing tar or other substances which might cause staining. If required to move stone, use wood rollers with cushions at end of wood slides.

B. Protect stonework during erection as follows:

1. Cover top of walls with non-staining waterproof sheeting at end of each day's work. Cover partially completed structures when work is not in progress. Extend cover a minimum of 24" down both sides and hold securely in place
2. Prevent staining of stone from mortar, grout, sealants and other sources. Immediately remove such materials without damaging stone.
3. Protect base of walls from rain-splashed mud and mortar splatter by means of coverings spread on ground and over wall surface.
4. Protect sills, ledges and projections from droppings of mortar and sealants.

1.15 COLD WEATHER PROTECTION

A. Comply with the following requirements:

1. Remove ice or snow formed on stonework beds by carefully applying heat until top service is dry to the touch.
2. Remove stonework damaged by freezing conditions

PART 2 - PRODUCTS

2.1 CONCRETE SLAB FOUNDATION

A. Concrete Core: Refer to 033001, CAST-IN-PLACE CONCRETE - SITEWORK.

2.2 STONE WALLS

A. W1: Highland Street Reconstructed wall:

1. Existing stone shall be reused in reconstruction to match existing pattern as much as possible. See civil drawings for wall reconstruction details.
2. All cap material to be new granite extending over re-built and newly constructed walls. Existing caps are not to be re-used, no concrete caps.
3. Stone caps shall be four inches thick as shown on drawings with eased edges and 1" overhang on both sides. All caps will be full width and a minimum length of 4'.
4. Coursing shall match existing wall, contractor to take photos of wall to closely match existing aesthetic.
5. Batter of wall as shown on drawings and shall be consistent between re-built and new walls.
6. Grout jointing in face of wall to be grapevine tooled, submit color samples for approval. Grouting material and methods shall be consistent between re-built and new walls.

B. W2: New wall along Highland Street:

1. Wall material to match existing W1 wall as much as possible with color, texture, size, dimension and batter.
   a. shall be new granite consisting of weathered greys, browns and some moss, free from seams, cracks, and other structural defects.
   b. Samples and specification information for each shall be submitted for approval.

2. Stone shall be sizes to match approved samples.
3. Minimum stone size shall be 4 in. thick by 6 in. long.
4. Stone caps shall be size and shape as per drawings and consistent between reconstructed wall and new wall.
5. Grout joints shall be consistent with reconstructed wall.

2.3 GRANITE CAP

A. Cap stone shall be Deer Isle, Rockport or Freshwater Pearl Granite.
B. Contractor to submit sample for approval
C. Finish shall be split face on vertical edges with eased, thermal finish on all corners and top. Cap shall be angled at a 1.5% pitch away from sidewalk to drain.
D. Cap joints shall be maximum 3/8" width, tooled concave to allow water to drain.
E. Full samples showing all face finishes and edge conditions shall be submitted for approval once a stone type is approved.

2.4 GRANITE PILLARS

A. Pillars to match stone wall construction with similar coursing.
B. Pillars to be square in dimension so that the width is determined by the width of the stone walls (assumed 18" – 2' square)
C. Caps to be same as wall caps with same overhang

2.5 STONE STAIR RECONSTRUCTION

A. Contractor and mason are to take photos and measurements of existing stair prior to removal to accurately replicate during reconstruction.
B. All treads and stone from stairs at Highland Street shall be salvaged for reconstruction.
C. Treads shall be cleaned to be free from moss and dirt so as to not be slippery.
D. Salvaged tread dimensions determine stair width and height.

E. Stairs shall be constructed on concrete foundation
F. Cheek walls adjacent to stair treads shall be constructed of salvaged cheek wall stone.
G. Cheek walls shall be 6” below top of Highland Street wall cap and return 90 degrees into the slope.
H. Top of Cap stone shall be 4” above highest tread (as per existing conditions)
I. Stone piers flanking top of stairs shall be minimum 12” height, this includes 4” cap and (1) 8” coursing of stone and match construction of stone walls.

2.6 STONE FABRICATION

A. General: Fabricate stone units in sizes and shapes required to comply with requirements indicated to match the re-built/existing wall face, including details on Drawings and Shop Drawings.

B. Control depth of stone and back check to maintain minimum clearance indicated between backs of stone units and surfaces of backup walls, and other work behind stone.

C. Dress joints (bed and vertical) straight and at right angle to face, unless otherwise indicated. Shape beds to fit supports.

D. Cut and drill sinkages and holes in stone for anchors, fasteners, supports, and lifting devices as indicated or needed to set stone securely in place.

E. Finish exposed faces and edges of stone to comply with requirements indicated for finish and to match approved samples and mockups.

F. Cut stone to produce uniform joints 3/8 inch maximum wide and in locations indicated.

G. Contiguous Work: Provide chases, reveals, reglets, openings, and similar features as required to accommodate contiguous work.

H. Clean backs of stone to remove rust stains, iron particles, and stone dust.

I. Inspect finished stone units at fabrication plant for compliance with requirements for appearance, material, and fabrication. Replace defective units.

1. Grade and mark stone for overall uniform appearance when assembled in place. Natural variations in appearance are acceptable if installed stone units match range of colors and other appearance characteristics represented in approved samples and mockups.

2.7 MORTAR MATERIALS

A. Portland Cement: ASTM C 150, Type I or II, except Type III may be used for cold-weather construction. Provide natural color or white cement as required to produce mortar color indicated.

1. Low-Alkali Cement: Not more than 0.60 percent total alkali when tested according to ASTM C 114.

B. Hydrated Lime: ASTM C 207, Type S.

C. Portland Cement-Lime Mix: Packaged blend of portland cement complying with ASTM C 150, Type I or III, and hydrated lime complying with ASTM C 207.

D. Mortar Pigments: Natural or synthetic iron oxides, compounded for use in mortar mixes and with a record of satisfactory performance in stone masonry mortars.

1. Available Products:

a. Bayer Corporation, Industrial Chemicals Div.; Bayferrox Iron Oxide Pigments.
b. Davis Colors; True Tone Mortar Colors.
c. Lafarge Corporation; Centurion Pigments.
d. Solomon Colors; SGS Mortar Colors.

E. Aggregate: ASTM C 144.

F. Water: Potable.

2.8 MORTAR MIX FOR SETTING STONE

A. General: Do not use admixtures, including pigments, air-entraining agents, accelerators, retarders, water-repellent agents, antifreeze compounds, or other admixtures, unless otherwise indicated.

1. Do not use calcium chloride.
2. Add cold-weather admixture (if used) at same rate for all mortar, regardless of weather conditions, to ensure that mortar color is consistent.

B. Mortar for Stone Masonry: Comply with ASTM C 270, Proportion Specification.

1. Limit cementitious materials in mortar to portland cement and lime.
2. Mortar for Setting Stone: Type S.

2.9 EPOXY GROUT

A. Colored Grout: Epoxy grout for joints shall be Laticrete "SpectraLock Pro Premium Grout", manufactured by Laticrete International, Inc., One LATICRETE Park North, Bethany, CT 06524-3423 USA · 1.800.243.4788 · +1.203.393.0010, or approved equal. Color will be selected by Architect from manufacturer's standard offerings.

1. Pointing mortar shall be Laticrete Masonry Pointing Mortar. Color will be selected by Architect.
2. Color shall match stone or be slightly darker.

2.10 METAL ITEMS

A. Steel angle support anchors for general use shall consist of continuous lengths of steel angles, indicated sizes, ASTM A 36, pre-drilled for anchor bolts, all as shown on the approved shop drawings. Steel support angles at exterior veneer work shall be hot dip galvanized after fabrication in accordance with ASTM A 123, with all field welds and/or field cuts shall be thoroughly cleaned to bare metal and prime painted with ZRC or zinc dust primer.

B. Anchors, cramps, dowels, shims, and other metal items required for the support and anchorage of the stone work shall be furnished under this Section.

C. Anchors, cramps, dowels, and other items to be set into concrete or masonry shall be furnished under this Section for installation under the concrete section or masonry section, as applicable. All other metal items shall be installed under this Section.

D. Anchors, cramps, dowels, shims, and other metal items, shall be AISI Type 304 stainless steel or suitable non-ferrous metal of the types and sizes shown on approved Shop Drawings.

E. Corrugated Metal Ties: Metal strips not less than 7/8 inch (22 mm) wide with corrugations having a wavelength of 0.3 to 0.5 inch (7.6 to 12.7 mm) and an amplitude of 0.06 to 0.10 inch (1.5 to 2.5 mm) made from steel sheet, galvanized after fabrication not less than 0.067 inch (1.7 mm) thick.

F. Cast-in-Place Concrete Inserts: Steel, cast iron, or malleable iron adjustable inserts, with bolts, nuts, washers, and shims; all hot-dip galvanized or mechanically zinc coated, with capability to sustain, without failure, a load equal to 4 times the loads imposed as determined by testing per ASTM E 488, conducted by a qualified independent testing agency.

2.11 MASONRY ANCHORS AND TIES

A. Unless otherwise specified by Structural Engineer, masonry ties shall be #345 Corrugated SS Buck Anchor Tie, manufactured by Hohman and Barnard, Inc., 30 Rasons Court, Hauppauge, NY 11788; (P) 631-234-0600; (F) 631-234-0683;Toll: 800-645-0616; Contact: Patricia Hohmann, or approved equal.

PART 3 - EXECUTION

3.1 CONCRETE

A. Concrete Foundation per structural notes for reinforcement: Refer to Section 033001, CAST-IN-PLACE CONCRETE - SITEWORK.

3.2 EXAMINATION

A. Examine areas and conditions under which work is to be installed. Do not proceed with the work until unsatisfactory conditions have been corrected.
B. Contractor to document coursing, dimensions, finish and all visible components of walls and stairs to be re-built.

3.3 PREPARATION

A. Advise installers of other work about specific requirements relating to placement of inserts, flashing reglets and similar items which will be used by Stonework Installer for anchoring, supporting and flashing of stonework. Furnish Installers of other work with drawings or templates showing locations of these items. Clean stone surfaces (new and salvaged) which have existing mortar or have become dirty or stained prior to setting to remove soil, stains and foreign materials. Clean stones by thoroughly scrubbing stones with fiber brushes followed by a thorough drenching with clear water. Use only mild cleaning compounds that contain no caustic or harsh filler or abrasives. Remove from the site those stone units with chips, cracks, voids, stains or other

defects which might be visible in the finished work. Reorder replacement pieces immediately.

3.4 SETTING FIELDSTONE, GENERAL

A. Before setting stone clean surfaces that are dirty or stained by removing soil, stains, and foreign materials. Clean stone by thoroughly scrubbing with fiber brushes and then drenching with clear water. Use only mild cleaning compounds that contain no caustic or harsh materials or abrasives.

B. Execute dimension stone cladding installation by skilled mechanics and employ skilled stone fitters at Project site to do necessary field cutting as stone is set and in accordance with the approved shop and setting drawings.

1. Use power saws with diamond blades to cut stone. Produce lines cut straight and true, with edges eased slightly to prevent snipping.

C. Contiguous Work: Provide reveals, reglets, and openings as required to accommodate contiguous work.

D. Set stone to comply with requirements indicated on Drawings and Shop Drawings. Install anchors, supports, fasteners, and other attachments indicated or necessary to secure dimension stone cladding in place. Shim and adjust anchors, supports, and accessories to set stone accurately in locations indicated with uniform joints of widths indicated and with edges and faces aligned according to established relationships and indicated tolerances.

E. Rough edged stone may be used in below grade/buried conditions as necessary.

F. Stone units with chips, cracks, stains, or other defects which might be visible in the finished work shall not be used.

G. Stone shall not be dropped upon or slid over masonry, nor shall hammering or turning of stones on the masonry be allowed. Stones shall be carefully set without jarring the stone already laid, and they shall be handled with a lewis or other appliance which will not cause disfigurement.

H. Securely anchor to back-up construction as indicated on the approved shop and setting drawings. Stone veneer shall be anchored with metal ties, as indicated. Exposed surfaces shall be kept free of mortar at all times.

I. Install stone veneer plumb; true to line; with level courses; straight, clean, uniformly wide joints; true surfaces; and straight plumb corners. Maintain horizontal and vertical alignment of joints.

J. Do not use installed stone veneer work to support or in any temporary supports.

K. Cooperate with Sheet Metal and Sealant trades, coordinating work of this Section with installation of related work.

L. Provide complete protection against breakage, staining, and weather damage during and after installation of the stone work by use of suitable, strong, impervious film or fabric securely held in place. Tops of stone shall be positively protected with non-

staining waterproof coverings, properly weighted, at night, during showers, and whenever stone setters are not working on the walls.

M. Maintain stone cladding work clean as the work progresses. Exercise extreme care at exposed work to prevent smearing or staining with mortar. Wash mortar stains immediately from exposed surfaces.

N. Provide expansion, control, and pressure-relieving joints of widths and at locations indicated.

1. Sealing expansion and other joints is specified in Section 079200, JOINT SEALANTS.
2. Keep expansion joints free of mortar and other rigid materials.

3.5 SETTING STONE VENEER WITH MORTAR

A. Set stone in full bed of mortar with head joints slushed full, unless otherwise indicated.

1. Do not set heavy units or projecting courses until mortar in courses below has hardened enough to resist being squeezed out of joint.
2. Support and brace projecting stones until wall above is in place and mortar has set.

B. Joints to be grapevine tooled to have shadow reveal along front of wall.

3.6 POINTING – WALL CAP STONE

A. Prepare stone-joint surfaces for pointing with mortar by removing dust and mortar particles. Where setting mortar was removed to depths greater than surrounding areas, apply pointing mortar in layers not more than 3/8 inch (10 mm) deep until a uniform depth is formed.

B. Point stone joints by placing and compacting pointing mortar in layers not more than 3/8 inch (10 mm) deep. Compact each layer thoroughly and allow to become thumbprint hard before applying next layer.

C. Tool joints, when pointing mortar is thumbprint hard, with a smooth jointing tool to produce the following joint profile:

1. Joint Profile: Smooth, concave face slightly below edges of stone to match Architect approved mockup. Tool joints so that water does not pool.

3.7 CLEANING

A. Stone work shall be carefully cleaned, removing all dirt, excess mortar, stains, and other defacements.

1. Mild abrasive cleaners that contain no harsh or caustic ingredients may be used, with fiber brooms or brushes and clear water. Wire brushes, steel wool, and acids or other solutions which may cause discoloration are expressly prohibited.
2. Expansion joints and other joints to receive sealant shall be cleaned of all mortar and left ready for sealing of joints under Section 079200, JOINT SEALANTS.

B. Upon completion of stone veneer work, surfaces shall be left in a clean, unsoiled

condition, acceptable to the Architect.

3.8 EXCESS MATERIALS AND WASTE

A. Excess Stone: Stack excess stone where directed by Owner for Owner's use.

B. Excess Masonry Waste: Remove excess clean masonry waste that cannot be used as fill, and other waste, and legally dispose of off Owner's property.

3.9 CONSTRUCTION WASTE MANAGEMENT

A. Comply with the requirements of Section 017419, CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL for removal and disposal of construction debris and waste.

END OF SECTION

Section 32 33 00

LANDSCAPE SITE FURNISHINGS

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01, GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.2 DESCRIPTION OF WORK

A. Provide all materials and equipment, and do all work necessary to furnish and install the site furnishings, as indicated on the Drawings and as specified.

1.3 RELATED SECTIONS

A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that directly relate to work of this Section include, but are not limited to:

1. Section 033001, CAST-IN-PLACE CONCRETE - SITEWORK.
2. Section 055001, METAL FABRICATIONS – SITEWORK.

1.4 REFERENCES

A. Comply with applicable requirements of the following standards. Where these standards conflict with other specified requirements, the most restrictive shall govern:

1. American Society for Testing and Materials (ASTM):

A 153 Zinc Coating (Hot-Dip) on Iron and Steel Hardware

1.5 SUBMITTALS

A. Provide submittals in accordance with Section 01 30 00 – Submittal Procedures.

B. Product data:

1. Manufacturer’s standard product literature.
2. Shop drawings listing model, size, and details.
3. Installation instructions.
4. Maintenance instructions.

C. Submit powder coat finish samples for approval.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications:

1. Minimum 15 years’ experience in the manufacture of the respective category of site furnishings.
2. Forest Stewardship Council (“FSC”) Certified Supplier. Provide manufacturer’s FSC certification number.

1.7 DELIVERY, STORAGE AND HANDLING

A. Handle products in accordance with manufacturer's instructions.

B. Store products in manufacturer's original packaging until ready for installation.

C. Protect products from impacts and abrasion during storage.

1.8 WARRANTY

A. Provide manufacturer's standard warranty:

1. Warranty terms: one year from date of substantial completion against defects in materials and workmanship.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Materials shall be the standard products of a manufacturer regularly engaged in the manufacture of such products. The materials provided shall be of a type with proven satisfactory usage for at least 2 years.

2.2 FASTENERS AND HARDWARE

A. Provide manufacturer's standard materials and accessories as required for assembly of units and as indicated on the assembly drawings. Provide unexposed aluminum, stainless steel or steel plates, angles, and supports as required for complete assembly. Separate dissimilar materials to prevent electrolytic action.

B. Fasteners and metal components shall be cadmium-plated steel or steel hot-dipped galvanized in accordance with ASTM A 153.

C. Exposed metal surfaces shall be finished in accordance with the requirements of Section 05 50 01, METAL FABRICATIONS - SITEWORK.

2.3 TRASH AND RECYCLING RECEPTACLES

A. Trash receptacles shall be one of the following:

1. The Maximum by MMCite, 2905 Westinghouse Blvd, Suite 100,Charlotte, NC 28273, o 704 995 1942. Litter and recycling bin with rain cover. MAU 556/MAU-B556, powder coat steel, colors, TBD. Tropical hardwood facing, with graphics for recycling and trash.
2. The Apex Litter/Recycling Receptacle by Forms + Surfaces, 800-451-0410, www.forms-surfaces.com. 36 gallon split stream configuration with powder coated lid and body, rain shield, insets in FSC 100% certified wood.
3. The Lexicon 1500 Series Waste and Recycling by Maglin, 999 18th Street, Suite 3000, Denver, CO 80202, www.maglin.com. 2 Streams - 1 x 32 and 1 x 16 gallons, rain shield and vinyl graphics. Powdercoat finish, color TBD.

B. Quantity: 8 Dual Units

2.4 BIKE RACKS

A. Bike rack shall be one of the following:
   1. Park-a-Bike, U CS200 Circle Series, Hoop Runner Bike Racks, by Ground Control Systems,
   2. Arc Rack by Dero, 888-337-6729, www.dero.com
   3. Orion by Belson Outdoors, www.belson.com 800-323-5664.

B. Quantity =as shown on drawings (minimum 15).

C. Product shall conform to the following specifications:
   1. Material: Galvanized steel.
   2. Mounting: Surface Mount
   3. Tubing: 2" Square

2.5 BIKE RACKS IN GARAGE

A. Bike rack shall be one of the following:
   1. RE-108 - Reading bike rack capacity 8 (total of 2 to accommodate 16 bikes) by Keystone Ridge Designs. Surface mount rails, powder coated Chromite color (submit samples for approval).
   2. Cycle Stall Basic rail rack by Dero, 888-337-6729, www.dero.com, Arc Rack, galvanized steel finish, Rail surface mount, 90 degree rack angle. 10 hoops for 20 bikes.
   3. 20 Bike Grid Bike Racks Double Sided with Couplers | Silver by Belson Outdoors, www.belson.com 800-323-5664, surface mount kit

B. Quantity = to accommodate 16-20 bikes

2.6 BENCHES

A. Wall mounted benches shall be in the shape and form as shown in the drawings. These items will be custom manufactured by one of the following companies through shop drawing review and coordination.
   1. MMCite USA, Inc., mmcité usa LLC, 2905 Westinghouse Blvd, Suite 100, Charlotte, NC 28273, o 704 995 1942. Custom Vera Solo bench Radii to be per drawings. Piano Key configuration, backless. Powder coat metal finishes color TBD, Jatoba wood seating.
   2. Maglin, 999 18th Street, Suite 3000, Denver, CO 80202, www.maglin.com: Custom Ogden Bench. Backless, ipe wood, front to back slats, wall mounted and cantilevered. Powdercoat finish on metal components, color TBD.
   3. Streetlife America LLC, streetlife@streelifeamerica.com, Philadelphia, PA, US T 1 215 247 0148. Solid Top Seat Curved benches, wall top mounted and cantilevered. Louro Gamela wood top, backless.

B. Straight Benches outside of gym shall be:
   1. Streetlife America LLC, streetlife@streelifeamerica.com, Philadelphia, PA, US T 1 215 247 0148. Solid Top Seat Curved or Straight (see locations) benches, free standing, surface mount. Louro Gamela wood top, backless.

2. Maglin, 999 18th Street, Suite 3000, Denver, CO 80202, www.maglin.com: Ogden Bench, straight, backedless, surface mounted square legs, ipe wood, front to back slats,5' length. Powdercoat finish on metal components, color TBD.
3. MM Cite: Woody bench backless, tropical hardwood, surface mounted standard 1400 mm length by MMCite, 2905 Westinghouse Blvd, Suite 100,Charlotte, NC 28273, o 704 995 1942

2.7 FIXED DINING TABLES

A. Fixed Dining Tables to be:

1. Columbus Circle tables (2 ADA, 11 non ADA) by SiteCraft. 43-02 Ditmars Blvd., 2nd Floor, Astoria, NY 11105, 718-729-4900, Fax: 718-482-0661, site-craft.com. Greenwood top and benches, powder coated finish, surface mounted. Colors TBD. Or approved equal..

PART 3 - EXECUTION

3.1 GENERAL

A. The Contractor shall verify that finished grades and other operations affecting mounting surfaces have been completed prior to the installation of site furnishings. Site furnishings shall be installed plumb and true, at locations indicated, in accordance with the approved manufacturer's instructions.

3.2 ASSEMBLY AND ERECTION OF COMPONENTS

A. Items shall be shipped knocked-down (KD), ready for site assembly. Packaged components shall be complete including all accessories and hardware. New parts shall be acquired from the manufacturer; substitute parts will not be accepted unless approved by the manufacturer. When the inspection of parts has been completed, the site furnishings shall be assembled and anchored according to manufacturer's instructions or as indicated. When site furnishings are assembled at the site, assembly shall not interfere with other operations or pedestrian and vehicular circulation.

3.3 ANCHORAGE, FASTENINGS, AND CONNECTIONS

A. Furnish metal work, mounting bolts or hardware in ample time for securing into concrete or masonry as the work progresses. Provide anchorage where necessary for fastening furniture or furnishings securely in place. Provide, for anchorage not otherwise specified or indicated, slotted inserts, expansion shields, and power-driven fasteners, when approved for concrete; toggle bolts and through bolts for masonry; machine and carriage bolts for steel; through bolts, lag bolts, and screws for wood. Do not use wood plugs in any material. Provide non-ferrous attachments for non-ferrous metal. Make exposed fastenings of compatible materials, generally matching in color and finish the fastenings to which they are applied. Conceal fastenings where practicable.

3.4 TESTING

A. Each site furnishing shall be tested to determine a secure and correct installation. A correct installation shall be according to the manufacturer's recommendations and by the following procedure: The Contractor shall measure the physical dimensions and clearance of each installed site furnishing for compliance with manufacturer's recommendations and as indicated. Site furnishings which do not comply shall be reinstalled. Fasteners and anchors determined to be non-compliant shall be replaced. A written report describing the results of the testing shall be provided.

END OF SECTION

SECTION 32 33 01

EXTERIOR ROUGH CARPENTRY

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01, GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.2 DESCRIPTION OF WORK

A. Provide all exterior rough carpentry work exposed to the weather, as indicated on the Drawings and as specified herein. Work shall include exterior miscellaneous rough carpentry including but not limited to the following items:

1. Support framing.
2. Rough hardware, inserts, and related metal components.
3. Rough carpentry blockings, curbs, cants, edgings, grounds, nailers, and furring.

1.3 RELATED SECTIONS

A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that directly relate to work of this Section include, but are not limited to:

1. Section 033001, CAST-IN-PLACE CONCRETE – SITEWORK.
2. Section 32 33 00 LANDSCAPE SITE FURNISHINGS

1.4 REFERENCES

A. Comply with applicable requirements of the following standards. Where these standards conflict with other specified requirements, the most restrictive shall govern:

1. American National Standards Institute (ANSI):

A199.1	Construction and Industrial Plywood

2. American Plywood Association (APA):

Ref. 1	APA Design/Construction Guide, Residential and Commercial

3. American Society for Testing and Materials (ASTM):

A 153	Zinc Coating (Hot-Dip) on Iron and Steel Hardware
D 226	Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing
D 245	Structural Grades and Related Allowable

	Properties for Visually Graded Lumber
D 2898	Accelerated Weathering of Fire-Retardant-Treated Wood for Fire Testing
E 84	Surface Burning Characteristics of Building Materials

4. Federal Specifications (Fed. Spec.):

UU-B-790	Building Paper, Vegetable Fiber (Kraft, Waterproofed, Water Repellent, and Fire Resistant)

5. U.S. Department of Commerce (USDC):

PS 1	Plywood
PS 20	American Softwood Lumber Standard

1.5 DEFINITIONS

A. Boards: Lumber of less than 2 inches nominal (38 mm actual) in thickness and 2 inches nominal (38 mm actual) or greater width.

B. Dimension Lumber: Lumber of 2 inches nominal (38 mm actual) or greater but less than 5 inches nominal (114 mm actual) in least dimension.

C. Timber: Lumber of 5 inches nominal (114 mm actual) or greater in least dimension.

D. Lumber grading agencies, and the abbreviations used to reference them, include the following:

1. NeLMA: Northeastern Lumber Manufacturers' Association.
2. NLGA: National Lumber Grades Authority.
3. RIS: Redwood Inspection Service.
4. SPIB: The Southern Pine Inspection Bureau.
5. WCLIB: West Coast Lumber Inspection Bureau.
6. WWPA: Western Wood Products Association.

1.6 SUBMITTALS

A. Shop Drawings: Submit shop drawings of wood blocking installation and other rough carpentry work. Describe proposed methods of installation and anchorage to structure showing sizes, types, thicknesses, connections of wood blocking and related items, including adjoining work by other trades.

1. Engineering: Provide signed and stamped drawings prepared by a professional engineer, registered in the Commonwealth of Massachusetts, to certify that work of this Section meets or exceeds performance requirements specified and/or required by code.
2. Contractor shall coordinate all shop drawings with other trades as required. Note that wood material will need to coordinate with actual size and not as ‘dimensional’ lumber.

B. Samples: Submit representative samples of all materials for use under this Section.

C. Product Data: Submit product data consisting of manufacturer's product description and specifications.

D. Certificates: Submit certificates of grading, treatment, and conformance to specified standards. Certifications shall state date of treatment, conformance with Specifications, and agency grading of wood.

1. For lumber specified to comply with minimum allowable unit stresses. Indicate species and grade selected for each use and design values approved by ALSC's Board of Review.
2. For preservative-treated wood products. Indicate type of preservative used and net amount of preservative retained.
3. Local/Regional Materials:
   a. Sourcing location(s): Indicate location of extraction, harvesting, and recovery; indicate distance between extraction, harvesting, and recovery and the project site.
   b. Manufacturing location(s): Indicate location of manufacturing facility; indicate distance between manufacturing facility and the project site.

1.7 QUALITY ASSURANCE

A. Provide lumber and plywood bearing the grade-trademark of the association under the rules or standards of which it was produced. Grade-trademarks shall conform to the rule or standard under which the material is produced, including requirements for qualifications and authority of the inspection organization, usage of authorized identification, and information included in the identification.

1. Grades specified are the minimum acceptable. Lumber grades shall be determined in accordance with ASTM D 245.
2. Lumber shall bear the grade mark of an American Lumber Standards Committee, Board of Review-approved agency. Lumber shall conform to USDC PS 20.
3. Lumber shall bear a mark of mill identification.
4. Plywood shall comply with APA Ref. 1 grading requirements, USDC PS 1, and ANSI A199.1.

B. Forest Certification: Provide wood products obtained from forests certified by an FSC-accredited certification body to comply with FSC STD-01-001, "FSC Principles and Criteria for Forest Stewardship."

1.8 COORDINATION

A. Coordinate the work of this Section with the work of other Sections to assure the steady progress of all the work of the Contract.

1.9 PRODUCT DELIVERY AND STORAGE

A. Stack and store materials above ground under protective coverings, or indoors in such a manner to insure proper drainage, ventilation, and protection. Do not place kiln dried materials in the building until concrete and masonry work have been completed and are sufficiently dry.

B. Store rough carpentry materials stickered in elevated piles with spacers to allow for air circulation below. Wrapped lumber completely, including bottoms, in waterproof tarps. Tie tarps down to protect against wind blow-off. Stored lumber in covered storage trailers during project delays.

PART 2 - PRODUCTS

2.1 LUMBER, GENERAL

A. Lumber: Comply with DOC PS 20 and with applicable rules of grading agencies indicated. If no grading agency is indicated, provide lumber that complies with the applicable rules of any rules-writing agency certified by ALSC's Board of Review. Provide lumber graded by an agency certified by ALSC's Board of Review to inspect and grade lumber under the rules indicated.

1. Factory mark each item with grade stamp of grading agency.
2. For items that are exposed to view in the completed Work, mark grade stamp on end or back of each piece.
3. In DOC PS 20, dressed sizes of green lumber are larger than dry lumber.
4. Where nominal sizes are indicated, provide actual sizes required by DOC PS 20 for moisture content specified. Where actual sizes are indicated, they are minimum dressed sizes for dry wood products.
5. Provide dressed lumber, S4S, unless otherwise indicated.

2.2 DIMENSION LUMBER

A. Maximum Moisture Content: 15 percent for 2-inch nominal (38-mm actual) thickness or less; 19 percent for more than 2-inch nominal (38-mm actual) thickness.

B. Exposed Lumber: Provide material hand selected for freedom from characteristics, on exposed surfaces and edges, that would impair finish appearance, including decay, honeycomb, knot holes, shake, splits, torn grain, and wane.

C. Framing: Construction or No. 2 grade and any of the following species:

1. Hem-fir (North); NLGA.
2. Locust
3. Southern pine; SPIB.
4. Douglas fir-larch; WCLIB or WWPA.

2.3 PRESERVATIVE

A. Pressure Type: Preservative: Wolman® E copper azole; provided by Arch Treatment Technologies, Inc., 1955 Lake Park Drive, Suite 250 Smyrna, GA 30080; Tel:770.801.6600;E-mail: info@wolmanizedwood.com • Web: www.wolmanizedwood.com, or approved equal.

1. Lumber shall be pressure treated with copper azole, conforming to AWPA Standard U1. Supply certificate of treatment to Architect.
2. Treatment: In accordance with the requirements of AWPA U1 Standard and in accordance with the following standards for indicated end uses:
   a. Application: UC4A Ground Contact.

3. Under no circumstances shall creosote, copper sulfate, arsenic, or mercuric chloride preservative be used.

2.4 BOARDS

A. Maximum Moisture Content: 19 percent.

B. Provide boards hand selected for freedom from characteristics, on exposed surfaces and edges, that would impair finish appearance, including decay, honeycomb, knot holes, shake, splits, torn grain, and wane.

2.5 FASTENERS

A. General: Provide fasteners of size and type indicated that comply with requirements specified in this article for material and manufacture. Provide nails or screws, in sufficient length, to penetrate not less than 1-1/2 inches (38 mm) into wood substrate.

1. All fasteners exposed to view shall be Type 316 stainless steel.
2. Use galvanized steel fasteners for concealed work only. All other fasteners shall be reviewed and approved by Architect. Any fastener to be used on pressure treated lumber shall be compatible with preservative treatment materials.

B. Nails: ASTM F 1667.

C. Power-Driven Fasteners: ICC-ES AC70.

D. Wood Screws: ASME B18.6.1.

E. Lag Screws: ASME B18.2.1 (ASME B18.2.3.8M).

F. Stainless-Steel Bolts: ASTM F 593, Alloy Group 1 or 2 (ASTM F 738M, Grade A1 or A4); with ASTM F 594, Alloy Group 1 or 2 (ASTM F 836M, Grade A1 or A4) hex nuts and, where indicated, flat washers.

2.6 METAL FRAMING ANCHORS

A. Allowable Design Loads: Provide products with allowable design loads, as published by manufacturer, that meet or exceed those of basis-of-design products. Manufacturer's published values shall be determined from empirical data or by rational engineering analysis and demonstrated by comprehensive testing performed by a qualified independent testing agency.

B. Stainless-Steel Sheet: ASTM A 666, Type 316.

C. Joist Hangers: Stainless steel U-shaped, with 2-inch- (50-mm-) long seat and 1-1/4-inch- (32-mm-) wide nailing flanges at least 85 percent of joist depth.

D. Top Flange Hangers: Stainless steel U-shaped joist hangers, full depth of joist, formed from metal strap with tabs bent to extend over and be fastened to supporting member.

E. Post Bases: Adjustable-socket type for bolting in place with standoff plate to raise post 1 inch (25 mm) above base and with 2-inch- (50-mm-) minimum side cover, socket 0.062 inch (1.6 mm) thick, and standoff and adjustment plates 0.108 inch (2.8 mm) thick.

F. Joist Ties: Flat straps, with holes for fasteners, for tying joists together over supports.

2.7 MISCELLANEOUS MATERIALS

A. Provide hammer drive anchors and fasteners for securing wood framing, blocking or plywood into masonry of sufficient length to meet structural requirements.

B. Building Felts: Provide 15 lb. asphalt saturated felts, non-perforated, conforming to ASTM D 226, Type I.

PART 3 EXECUTION

3.1 GENERAL PRECAUTION

A. Deck framing is to be installed on adjustable pedestals over rubber roof membrane. Special care shall be taken to ensure that membrane is not damaged during these construction operations.

3.2 EXAMINATION

A. Do not begin installation until substrates have been properly prepared.

B. If substrate preparation is the responsibility of another installer, notify Architect of unsatisfactory preparation before proceeding.

C. Verify all elevations, required pedestal heights and deck dimensions before commencing work.

3.3 ROUGH CARPENTRY WORK, GENERAL

A. Refer to Drawings to determine the major extent of the rough carpentry work required.

B. The Contractor shall be responsible for structural integrity, connections, and anchorage of rough carpentry work.

C. Discard units of material which are unsound, warped, bowed, twisted, improperly treated, not adequately seasoned, or too small to fabricate.

D. Set rough carpentry work to required levels and lines, with members plumb and true to line, cut and fitted.

E. Provide wood sleepers, blockings, curbs, cants, edgings, grounds, nailers, and furring where required for screeding or attachment to other work. Coordinate locations with other work to be supported.

F. Attach to substrates as required to support applied loading.

G. Provide permanent grounds of dressed, preservative treated, key-bevelled lumber not less than 1-1/2 in. wide, and of thickness required.

H. Unless indicated otherwise, blockings, nailers, etc., of 2 in. nominal thickness or greater

shall be bolted to back-up material with 1/2 in. bolts (Type 316 stainless steel at exterior locations and at roofs) located 4 in. from ends and splices, and spaced not greater than 16 in. on center along lengths of the members. Provide nails of sufficient length to penetrate receiving member to meet structural requirements, but not less than 1-1/2 in.

I. Unless indicated otherwise, secure 2 in. thick or smaller wood framing, nailers, furring, etc., to back-up material by use of appropriate fasteners located 4 in. from ends and spaced not greater than 16 in. on center along lengths of the members. Provide type and length of fastening devices to develop positive and secure anchorage to the back-up material.

J. Butt joints in wood shall be flush to provide smooth, uniform line with no irregularities. Built-up blocking shall have butt joints staggered 4 in. minimum layer to layer. The minimum length of any individual piece of lumber shall be 12 in. Lengths of lumber shall have a minimum of four fasteners.

K. Construct all rough carpentry work plumb, level, and true with tight, close fitting joints, securely attached and braced to surrounding construction. Counterbore for bolt heads, nuts, and washers where required to avoid interference with other materials.

L. Repair all damage caused by nailing, drilling, or powder-driving into concrete or masonry.

3.4 INSTALLATION, GENERAL

A. Set exterior rough carpentry to required levels and lines, with members plumb, true to line, cut, and fitted. Fit exterior rough carpentry to other construction; scribe and cope as needed for accurate fit.

B. Framing Standard: Comply with AF&PA's "Details for Conventional Wood Frame Construction" unless otherwise indicated.

C. Do not splice structural members between supports unless otherwise indicated.

D. Provide blocking and framing as indicated and as required to support facing materials, fixtures, specialty items, and trim.

E. Sort and select lumber so that natural characteristics will not interfere with installation or with fastening other materials to lumber. Do not use materials with defects that interfere with function of member or pieces that are too small to use with minimum number of joints or optimum joint arrangement.

F. Comply with AWPA M4 for applying field treatment to cut surfaces of preservative-treated lumber.

1. Use inorganic boron (SBX) for items that are continuously protected from liquid water.
2. Use copper naphthenate for items not continuously protected from liquid water.

G. Securely attach exterior rough carpentry work to substrate by anchoring and fastening as indicated, complying with the following:

1. ICC-ES AC70 for power-driven fasteners.

2. Table 2305.2, "Fastening Schedule," in BOCA's BOCA National Building Code.

H. Use common wire nails unless otherwise indicated. Select fasteners of size that will not fully penetrate members where opposite side will be exposed to view. Make tight connections between members. Install fasteners without splitting wood; do not countersink nail heads unless otherwise indicated.

I. For exposed work, arrange fasteners in straight rows parallel with edges of members, with fasteners evenly spaced, and with adjacent rows staggered.

J. Indicate locations of other fasteners, such as wood screws, bolts, and lag screws, on Drawings.

3.5 CLEANING

A. Upon completion of rough carpentry work in any given area, remove all rubbish and debris from the work area and leave in broom clean condition.

END OF SECTION

SECTION 32 84 00

IRRIGATION

PART 1 - GENERAL

1.01 WORK SUMMARY

A. Provide all materials, labor, installation equipment, and technical service to complete construction of automatic, soil moisture-based, landscape irrigation system, coordination of installation by licensed plumbers and electricians where required, as well as testing and guarantee of irrigation system as defined below and in Construction Drawings.

B. Items of work specifically included are:
1. Procurement of all applicable licenses, permits, and fees.
2. Coordination of all utilities and licensed tradespersons to install work.
3. Acquisition of all materials.
4. Verification of site conditions.
5. Maintenance during guarantee period.
6. Connection of electrical power supply to irrigation control system.

C. Refer to abide by forms and conditions of overall contract as provided by Construction Manager, and applicable parts of Division 1 - GENERAL REQUIREMENTS.

1.02 QUALIFICATIONS

A. Qualified irrigation system installers must have five (5) years of experience minimum with work and products specified herein, including:
1. Two-Wire Controller and Valve Installation
2. Weather-Based and Smart Controllers
3. Solvent Weld and/or Gasket Joint PVC Pipe 2-inches and Greater
4. Commercial/Municipal Irrigation Systems
5. Qualifications: Submit qualification package as requested by Owner's Representative. Qualifications package must include:
a. Three (3) references for similar work described under Section 1.2 Qualifications performed in last five (5) calendar years.
1) Contact name
2) Company Name
3) Contact Phone Number
4) Project Name and Location
5) Brief Work Description

1.03 UTILITIES AND CONDITIONS

A. Water Service Point of Connection

1. New domestic water service from building water main to be provided by Plumbing Contractor with Room D109. Refer to Division 22 Plumbing. Approximate exterior point of connection location is noted on Construction Drawings.
    a. Equipment requirements provided by plumbing:
        1) 2-Inch Water Meter
        2) 2-Inch Backflow Preventer
        3) 2-Inch Water Service
    b. Flow and pressure requirements at outdoor point of connection:
        1) Flow: Maximum 60 gallons per minute (gpm)
        2) Pressure: 71 pounds per square inch (psi) dynamic pressure outdoors (downstream of all indoor equipment)
        3) Estimated Pressure Downstream of Backflow Preventer: 50 psi

B. Electrical Power Source to Indoor Controller
1. New electrical circuits to be provided by Electrical Contractor (Refer to Division 26 Electrical).
    a. Power Requirements for Irrigation Controller
        1) 120-Volt, 1-Phase, 60-Hz, 20-Amp
    b. Conduits for valve wire to exterior point of connection

C. Communications to Indoor Irrigation Controller
1. Communications to be provided by Communications Contractor (Refer to Division 27 Communications).
    a. Communication Requirements for Irrigation Controller
        1) Ethernet CAT/5 Cable to Local Area Network
        2) BACNet Communication with Building Management System (BMS)

D. Pipe Sleeves
1. Coordinate pipe sleeves to be provided by Earthwork Contractor beneath all hardscape, as indicated on Construction Drawings.
    a. Pipe sleeve requirements
        1) Two (2) parallel 4-inch Schedule 40 PVC
        2) Extend 18 inches beyond edge of hardscape
        3) Minimum cover: 24 inches

1.04 RELATED REQUIREMENTS

A. Coordinate with other trades and refer to overall Construction Document Specifications and Drawings, including, but not limited to:
1. Division 01 – General Requirements
2. Division 02 – Existing Conditions
3. Division 03 – Concrete
4. Division 22 – Plumbing

5. Division 26 – Electrical
6. Division 27 – Communications
7. Division 31 – Earthwork
8. Division 32 – Exterior Improvements
9. Division 33 – Utilities
10. Construction Drawings:
    a. IR-1 – Irrigation Plan
    b. IR-2 – Irrigation Plan
    c. IR-3 – Irrigation Details
    d. Review construction documents of other pertinent trades for coordination.

1.05 APPLICABLE STANDARDS AND CODES

A. At minimum, comply with following standards and codes:
    1. American Society for Testing and Materials (ASTM)
    2. National Standard Plumbing Code (NSPC)
    3. National Electric Code (NEC)
    4. National Sanitary Foundation (NSF)
    5. Underwriters Laboratories, Inc. (UL)
    6. Occupational Safety and Health Administration (OSHA)

B. Comply with applicable laws, standards, and regulations of local governing authority. All local laws more stringent than those referenced above take precedent.

1.06 SUBMITTALS

A. Submit under provisions of General Conditions:
    1. Literature: Manufacturer's product data sheets, specifications and installation instructions for materials listed in this Specification (Part 2 – Products).
        a. Provide concise product submittals (no extraneous pages or sections) and clearly marked to show submitted product model, type, and size.
        b. Substitute Product Submittal:
            1) Provide specified product submittals for “an approved equal” to Owner’s Representative for approval.
            2) Alternate products are acceptable when products of equal or better quality and performance are submitted and approved by Owner’s Representative.
            3) Substitute Product Submittals constitute representation that:
                a) Substitute products have been thoroughly investigated and have been determined to be equal or superior in all respects to that specified.
                b) Substitute products have same warranties as specified products.
                c) Substitute products are compatible with interfacing items.

d) Assume responsibility of and guarantee system performance because of product substitution, including making all subsequent changes to meet design specifications.

c. Do not commence work until all products specified are submitted and approved in writing by Owner's Representative.

d. Install only new product without defects and of quality and performance as specified.

2. Schedule: Submit Schedule of all products to be furnished hereunder, indicating manufacturer, size, and model.

a. Ensure that all types/styles of products and installation equipment specified herein can be furnished by manufacturer submitted.

b. Provide all spare irrigation parts as noted (see Spare Irrigation Parts)

c. Prior to submitting schedule, confirm current site conditions are as provided in Construction Drawings.

1.07 DELIVERY, STORAGE AND HANDLING

A. Do not deliver materials to site until all specified submittals have been submitted to and approved by Owner's Representative.

B. Coordinate with Owner's Representative for temporary storage and staging areas.

C. Protect materials from damage from construction traffic, weather, corrosion, and other causes while stored on-site. Minimize on-site storage as possible.

D. Store and handle all products and materials in compliance with manufacturer instructions and recommendations.

1.08 GUARANTEE AND REPLACEMENT

A. Guarantee entire irrigation system, parts, and labor, for one (1) year from official written date of acceptance by Owner's Representative. Provide written warranty showing date of completion and period of warranty prior to request for final payment.

B. Correct all system malfunctions occurring during guarantee period due to defective materials, poor workmanship, or improper adjustment to satisfaction of Owner's Representative at no additional cost.

1. Repair all defects within 10 days of notification from Owner or Owner's Representative.

2. Repair defects with approved products.

C. Include first-year spring system start-up and winterization in system guarantee.

D. Provide certification of manufacturer warranties for all products and materials where such warranties are offered in published product data. Include copies of manufacturer warranties in Operations & Maintenance Manual (See Operation and Maintenance).

PART 2 - PRODUCTS

2.01 AUTOMATIC IRRIGATION CONTROLLER

A. Controller

1. Size: 200-Station Two-Wire Devices Maximum
2. Construction: Electronic with 120-Volt Input and 24-28 Volt Output; Plastic, Locking Wall-Mounted Enclosure
3. Standards: UL-Listed
4. Features: Manual and Automatic Control, Soil Moisture Sensor Feedback and Watering Basis, Water Budgeting, Cycle-Soak, Sensor Input Terminals, Internal Transformer, Flow Monitoring Capability, Lightning Protection, Remote Control, Two-Wire System with Conventional Wire Retrofit Capability.
5. Manufacturer/Model: Manufacturer/Model: Baseline BL-3200; or Approved Equal.

B. External Devices

1. Remote Control and Access
   a. Manufacturer/Model: Baseline BaseManager 2.0 Web Application (for use with Computer, tablet, or smartphone); or Approved Equal
   b. Coordinate BACNet Communication with Building Management System
2. Web-Enabled Device (Purchase and Provide to Owner for Remote Management in Field)
   a. Type: Tablet
   b. Size: 12.9-Inch, 256 GB Storage
   c. Communications: Wi-FI and Cellular Capability (Owner to connect to their cellular plan).
   d. Features: Otterbox (or Equal) outer cover for drop protection, stylus/pencil to write notes on electronic plans and saved maintenance logs and checklists
   e. Manufacturer/Model: Apple, Model iPad Pro, or Approved Equal
3. Wireless Rain Sensor
   a. Manufacturer/Model: Rain Bird WR2-RC; or Approved Equal
4. 2-Inch Flow Sensor Unit
   a. Manufacturer/Model: Baseline Control Point PFS with Flow Sensor and 4-20 mA Pressure Gauge with Decoders
5. Soil Moisture Sensors
   a. Manufacturer/Model: Baseline Biosensor BL-5315; or Approved Equal
6. Decoders
   a. Manufacturer/Model: Baseline BL-5201, BL-5202, and BL-5204; or Approved Equal
7. Surge Suppression / Lightning Arrestor
   a. Manufacturer/Model: Manufacturer/Model: Baseline BL-LA01

2.02 WIRE

A. Two-Wire (From Controller to Decoders)
   1. Size: 14/2 AWG Minimum
   2. Construction: Dual Strand Solid Copper Conductors with PVC Insulation and Poly Jacket.
   3. Ratings: UL-Listed, NEC (Class II Circuit), Direct Burial UF/TWU, up to 600-Volt Potential
   4. Standards: ASTM B-3, ASTM B-8
   5. Markings: Manufacturer, Rating, Size, and Type
   6. Manufacturer/Model: Coleman Cable #51452; Paige P7072D, P7296D, P7350D, and P7354D; Regency 14/2 and 12/2 Maxi Cable; Hunter Decoder Jacketed; Service Wire Company DEC12/2BE and DEC 14/2BE; or Approved Equal.

B. Conventional Wire (From Decoders to Electric Zone Valves)
   1. Size: 14AWG Minimum
   2. Construction: Single Strand Solid Copper Conductor with PVC Insulation
   3. Ratings: UL-Listed, NEC (Class II Circuit), Direct Burial UF/TWU, up to 600-Volt Potential
   4. Standards: ASTM B-3, ASTM B-8
   5. Markings: Manufacturer, Rating, Size, and Type
   6. Manufacturer/Model: Paige Electric Model P7001D; Service Wire Company UF14, UF12; Regency Wire & Cable 14AWG, 12AWG; or Approved Equal.

C. Wire Splices
   1. Type: Direct Burial Wire Splice Kit (All Components Intact)
   2. Construction: Lockable Plastic Tube, Pre-Filled with Insulation Gel
   3. Ratings: UL-Listed, NEC, Direct Burial and Submersion, up to 600-Volt Potential
   4. Manufacturer/Model: 3M DBY-6; Rain Bird DB Series; or Approved Equal.

D. Decoder Cable Fuse Device
   1. Type: Direct Burial Quick Disconnect Signal Splitter with 5-Amp Fuses
   2. Construction: Waterproof PVC with O-Ring Seal and ACME Threads
   3. Manufacturers: Paige Wire DCFD; or Approved Equal

E. Wire Conduit
   1. Size: 1-Inch Minimum
   2. Construction: PVC, Solvent Weld
   3. Ratings: Schedule 40
   4. Fittings: Long Sweep Elbows
   5. Manufacturer: Cresline; Certainteed, JM Eagle; or Approved Equal.

2.03 PIPE AND FITTINGS

A. Irrigation Mainline and Laterals
1. Size: 2.5-Inch Mainline, Laterals with Size as Noted on Construction Drawings
2. Construction: Polyvinyl Chloride (PVC), Solvent Weld
3. Ratings: Class 200 PVC SDR21
4. Markings: Manufacturer, Nominal Size, Class or Schedule, Pressure, Extrusion Date, Pipe Insertion Mark.
5. Manufacturer: Cresline; Certainteed; JM Eagle; or Approved Equal.

B. Fittings
1. Ratings:
a. For Valves Toe Nipples: Schedule 80 PVC
b. Other Fittings: Schedule 40 PVC
2. Markings: NSF Designation, Size, Class or Schedule
3. Manufacturer: Lasco; Spears; Dura; or Approved Equal

C. Solvent
1. Type: NSF Type I or Type II PVC
2. Standards: ASTM D-2564
3. Manufacturer: IPS Weld-On 711; Oatey HD Cement; Rectorseal Gold; or Approved Equal

D. Primer
1. Type: NSF for PVC
2. Standards: ASTM F-656
3. Manufacturer: IPS Weld-On P-68; Oatey Clear Primer; Rectorseal Jim PR-2; or Approved Equal

E. Small Lateral
1. Size: 1½-inch Maximum
2. Construction: Polyethylene (PE) 3408
3. Ratings: Class 100, Type III, SDR 15, Class C
4. Standards: ASTM D-2239
5. Colors: Black
6. Fittings: PVC Insert (per ASTM D-2609) with Stainless Steel Clamps on Each Side
7. Markings: Manufacturer, Nominal Size, Class or Schedule, Pressure, Extrusion Date, Pipe Insertion Mark
8. Manufacturers: Oil Creek; Certainteed; JM Eagle; or Approved Equal. Insert Fittings: Lasco, Dura, or Approved Equal. Clamps: Oetiker, or Approved Equal

2.04 ELECTRIC ZONE VALVES

A. Sprinkler Zone Valve
1. Size: 1-Inch (up to 20 gpm), 1½-Inch (up to 40 gpm), and 2-Inch (over 40 gpm)
2. Construction: Plastic Globe Valve with Reinforced Nylon or Fiberglass Body
3. Ratings: 200 psi
4. Features: Manual Bleed Screw, Flow Control, Pressure Regulation, and Filter/Scrubber
5. Manufacturer/Model: Hunter ICV-FS; Rain Bird PESB; or Approved Equal

B. Drip Zone Valve (Kit)
1. Size: 1-Inch
2. Construction: Plastic Diaphragm with Reinforced Nylon or Fiberglass Body
3. Ratings: 200 psi with Minimum Flow of 0.2 gpm
4. Features: Manual Bleed Screw, Flow Control, Pressure Regulation, and Stainless Steel Screen Filtration to 100 micron (150 mesh)
5. Manufacturer/Model: Hunter PCZ; Rain Bird XCZ; or Approved Equal

2.05 ISOLATION VALVES

A. Small PVC Mainline Isolation Valve
1. Size: 2-Inch and Smaller
2. Construction: Bronze, Gate Valve
3. Ratings: 200 psi
4. Features: Steel Cross Handle, Non-Rising Stem
5. Manufacturer/Model: Nibco T-113K; Apollo 102T-K; or Approved Equal

2.06 QUICK COUPLING VALVES

A. Small Mainline Quick Coupling
1. Size: 1-Inch, Normally Closed
2. Construction: Brass, Spring-Loaded Valve Seat, Key Engaged
3. Ratings: 125 psi
4. Features: 1-Inch NPT Inlet, ACME Key, Locking Vinyl Cover, Anti-Rotation Stabilization Wings
   a. Swing Joint Assembly
      1) Size: 1-Inch
      2) Construction: PVC, with O-Ring Seals and Brass Threaded Outlet
      3) Manufacturer: Hunter HSJ-1 with SnapLok; or Approved Equal
5. Manufacturer/Model: Hunter HQ-44RC-AW; or Approved Equal.

2.07 BALL VALVES

A. Indoor Winterization Port and Drain Valve
1. Size: 1-Inch, normally closed
2. Construction: Brass, Steel Tee Handle, Standard Port

3. Ratings: 600 psi
4. Features: Blow-Out-Proof Stem, Plated Brass Ball.
5. Manufacturer/Model: Apollo 70-105-01; or Approved Equal

2.08 VALVE BOXES

A. General

1. Size:
   a. 12-Inch Standard Valve Box
      1) Single 2-Inch Electric Zone Valve
      2) Double 1-Inch or 1½-Inch Electric Zone Valves
   b. 6-Inch Round
      1) Wire Splice
      2) Decoder Cable Fuse Device
      3) Decoder Grounding Rod
   c. 10-Inch Round
      1) Single 1-Inch or 1½-Inch Electric Zone Valve
      2) Isolation Valve
      3) Quick Coupling Valve
2. Construction: Resin
3. Ratings: Tensile Strength 3,000-5,000 psi
4. Color: Green or Black (per Owner's Representative)
5. Features: Lockable, Bolt-Down Covers, Brick Supported
6. Manufacturer/Model: Carson, Model Specification Grade NDS Pro; Rain Bird VB; or Approved Equal

2.09 SPRAY SPRINKLERS

A. Body

1. Size: 6-inch Pop-Up (Turf), 12-Inch Pop-Up (Shrubs and Groundcovers)
2. Construction: Plastic, Ratcheting Riser, Removable Nozzle, Internal Check Valve
3. Ratings: Pressure Regulated to 30 psi
4. Manufacturer/Model: Hunter PROS-XX-PRS30-CV; Rain Bird 18XX-SAM-PRS, or Approved Equal

B. Nozzles

1. Size: 5' – 17' Radius (see Construction Drawings)
2. Features: Full and Part-Circle Fixed-Arc and Strip Patterns
3. Manufacturer/Model: Hunter Pro Spray; Rain Bird MPR; Toro Precision; or Approved Equal

C. Swing Joint

1. Mandatory Swing Pipe Assemblies between 6 – 18 inches

2.10 ROTARY NOZZLE SPRINKLERS

A. Body
1. Size: 6-Inch Pop-Up (Turf), 12-Inch Pop-Up (Shrubs, Groundcovers, Meadow Grass)
2. Construction: Plastic, Ratcheting Riser, Removable Nozzle, Internal Check Valve
3. Ratings: Pressure Regulated to 40 psi
4. Manufacturer/Model: Hunter PROS-XX-PRS40-CV; Rain Bird 18XX-SAM-PRS-P45, or Approved Equal

B. Nozzles
1. 12' – 30' Radius (see Construction Drawings)
2. Features: Full and Part-Circle Fixed-Arc and Strip Patterns
3. Manufacturer/Model: Hunter MP Rotator, Toro Precision Rotating, or Approved Equal

2.11 DRIP IRRIGATION

A. Integral Emitter Drip Tubing
1. Type
a. Planter Beds
1) Tubing: 17mm Diameter
2) Emitters: 12-Inch Spacing at 0.6 gal/hour
3) Row Spacing: 18 Inches
b. Tree Drip Rings
1) Tubing: 17 mm
2) Emitters 12-Inch Spacing at 0.9 gal/hour
3) Diameters: As shown on Construction Drawings
c. Blank Tubing
1) Tubing: 17mm Diameter
2) Emitters: none
2. Construction: Polyethylene (PE) with Embedded Pressure Compensating Emitters
3. Ratings: Minimum Bending Radius = 7-inches
4. Fittings: 17mm PVC Barbed Fittings with Stainless Steel Clamps, Corrosion Tubing Stakes to Secure Drip Tubing to Ground
5. Features: Check Valve
6. Manufacturer/Model: Netafim TLCV6-12, TLCV9-12, and TLCV0; or Approved Equal

B. Distribution Tubing
1. Size: ¼-Inch
2. Construction: UV-Resistant Polyethylene Resin
3. Fittings: For Use with Barbed Emitters
4. Manufacturer/Model: Rain Bird XQ; or Approved Equal

C. Tree Drip Emitter
   1. Size: 0.5, 1.0, and or 2.0 gph (see Construction Drawings)
   2. Construction: UV-Resistant Plastic
   3. Features: Self-Piercing, Pressure Compensating, Color Coded to Identify Flow Rate
   4. Manufacturer/Model: Rain Bird PC; or Approved Equal

D. Drip Stake
   1. Size: 14-Inches Long
   2. Construction: Recycled ABS Plastic
   3. Fittings: Screw Top Cap
   4. Manufacturer/Model: Green King Deep Drip Stake; or Approved Equal

E. Automatic Flushing Valve
   1. Size: 1-Gallon Flush
   2. Construction: Plastic
   3. Fittings: 17mm PVC Barbed Fittings
   4. Manufacturer/Model: Netafim TLFV-1; or Approved Equal

2.12 EARTH MATERIALS

A. Stone (in Valve Boxes)
   1. Type: ¾-Inch (minimum) Crushed Stone

B. Clean Sand
   1. Gradation: (passing by weight)
      a. No. 4 Sieve= 80% Minimum
      b. No. 200 Sieve = 5% Maximum

C. Concrete
   1. Ratings: 3,000 psi 28-day Compressive Strength
   2. Standards: ASTM C-33, ASTM C-94, ASTM-C150

2.13 SPARE PARTS

A. Quick Coupler Valve Keys (2)

B. Gate Valve (1)

C. Integral Emitter Drip Tubing (100' Roll)

D. Drip Flush Valve (2)

E. Elbow, Tee, and Adapter Drip Barbed Fittings (5 Each)

F. Stainless Steel Clamps (4)

PART 3 - EXECUTION

3.01 GENERAL

A. Provide competent superintendents and assistants on-site during product delivery, installation, testing, and system adjustments.

1. Field communication by Owner or Owner's Representative to superintendent is binding. Provide written documentation of such communication as soon as possible.

B. Install system features as indicated on Construction Drawings, making minor adjustments for variations in planting arrangements or field conditions. Review major changes with Owner's Representative before continuing installation.

1. Irrigation lines shown on Construction Drawings are diagrammatic only. Location of irrigation equipment is contingent upon and subject to integration with all other underground utilities, tree roots, and hardscape design elements.

3.02 EXAMINATION

A. Review and verify site conditions are as indicated on Construction Drawings prior to starting work, including but not limited to:

1. Utilities provided by Others
2. Site grades and dimensions
3. Landscaping and features
4. Structures
5. Pipe sleeves

B. Report any irregularities of site conditions to Owner's Representative prior to beginning work.

C. Beginning of installation connotes acceptance of existing site conditions.

3.03 PROJECT COORDINATION

A. Coordinate with Owner's Representative to expeditiously install system.

B. Provide written notifications (electronic is acceptable) to Owner's Representative prior to work commencement, weekly for progress report, for any proposed changes to system design, and upon installation completion.

C. Provide in writing all questions of design intent, proposed design changes, field notifications, and product substitution after installation commences to Owner's Representative through Request for Information (RFI) process.

D. Utility Coordination:

1. Maintain 6-inch minimum clearance between irrigation lines and any utility line. Do not install sprinkler lines directly above another utility of any kind.
2. Exercise care when excavating, trenching, and working near existing utilities.

3.04 SITE PROTECTION

A. Protect landscaping, paving, structures, walls, footings, and other site furnishings from damage caused during work. Report all damage to work of other trades at once.

B. Replace or repair any damage with same product or material, to satisfaction of Owner's Representative at no additional cost to Owner per guarantee.

C. Route pipe as necessary to prevent damage to tree roots. Where trenching must occur near trees, provide proper root pruning and sealing methods to all roots 1-inch and larger.

3.05 EXCAVATION, TRENCHING, AND BACKFILLING

A. Notify and request approval from Owner's Representative prior to pipe pulling. Pipe pulling is acceptable only under these conditions:
   1. Maximum pipe size 2 inches
   2. Suitable soils with naturally rounded loamy soils and without sharp rocks
   3. Specified pipe burial depth can be maintained

B. Pipe Trench
   1. Excavate trenches straight and true, minimizing site disturbance as possible.
   2. Ensure final trench bottom consists of undisturbed soil free of rocks and debris larger than 1 inch or with sharp edges. Unsuitable undisturbed soil trench bases may be over-excavated 2 inches below pipe invert and refilled with Clean Sand or Stone as new pipe base.

C. Clean Backfill
   1. Material: Clean Sand (See Earth Materials)
      a. Clean backfill must be free of foreign material, debris, frozen material and rocks larger than 1-inch.
   2. Carefully place clean backfill to minimum depth of 10-inches over pipe and wire, tamp in place.
   3. Carefully place material around pipe and wire, tamp in place.

D. Trench Backfill
   1. Material: Re-use excavated material
      a. Clean backfill must be free of foreign material, debris, frozen material, and rocks larger than 1-inch.
   2. Place and compact in maximum 6-inch lifts to dry density equal to undisturbed soil. Compaction by truck or equipment tires is prohibited.
   3. Avoid backfilling in hot weather.
   4. Match adjacent subsurface grades without hills or depressions. Repair settling (as required by Guarantee).
   5. If final planting soils, mulch, or sod were removed or disturbed during trenching, replace to Owner's specifications, and regrade as necessary.
      a. Use sod cutter where applicable or reseed disturbed areas to Owner's acceptance.

3.06 PIPE INSTALLATION

A. PVC Pipe Installation

1. Cut plastic pipe with handsaw or pipe cutter, removing all burrs at cut ends, square and true. Bevel cut end as required to conform to manufacturer instructions.
2. Make all solvent-weld joints as per manufacturer's instructions and avoid applying excess primer or solvent. Do not wipe off excess solvent from each connection.
   a. Allow welded joints minimum 5 minutes set-up/curing time before moving or handling.
      1) Above 80°F: Allow connections to set 24 hours.
      2) Below 80°F: Follow manufacturer instructions.
      3) Below 40°F: Prohibited.
3. Do not exceed manufacturer limits for maximum deflection per joint.
4. Maintain 1-inch minimum between lines which cross at angels of 45 to 90 degrees

B. PE Lateral Pipe Preparation

1. Cut PE pipe with pipe cutter, removing all burrs at cut ends. All pipe cuts are to be square and true.
2. Clean ends as per manufacturer instructions.
3. Push PE pipe through stainless steel clamp—do not clamp at this point.
4. Soften PE pipe in hot water as per manufacturer recommendations for insert barbed fittings. Use of propane blowtorches to soften PE ends for fittings constitutes assumption of responsibility for and warranty of all PE pipe to same level as manufacturer.
5. Do not use lubricants or pipe dope with PE pipe.
6. Insert barbed fittings fully and position stainless steel clamp over barbs. At this time, crimp or screw worm gear clamps down with appropriate tools to secure pipe and fitting.
7. Where PE Lateral is proposed in structural soil, use TWO (2) CLAMPS per fitting.

C. Run wire in same trench as mainline at pipe invert (See Wire Installation).

D. PVC Pipe Cover (unpaved surfaces):

1. PVC Mainline = 22 inches
2. PVC Lateral = 16 inches

E. Pipe Protection:

1. Prevent foreign material from entering pipe during installation.
2. Close open ends by watertight plug or seal when not in use.
3. Securely store pipe when not scheduled for installation.
4. Do not install pipe when water is in trench, during rainstorms, or when temperature is below 40^0F.

a. No additional pipe may be installed or backfilled when water enters trench during pipe installation. Remove all water from trench before resuming installation.
b. Remove all pipe installed at temperatures below 40 ºF and replace at no cost to owner.

5. Snake trenched PVC pipe to accommodate for expansion and contraction due to changes in temperature.

3.07 PIPE SLEEVE INSTALLATION

A. Coordinate with Owner's Representative for provided pipe sleeves and locations installed by Earthwork Contractor.

B. New Pipe Sleeves:
1. Pipe Sleeve Cover: Minimum 24 inches
2. Install pipe sleeves where irrigation pipe runs under hardscape (see Construction Drawings).
3. Extend pipe sleeves minimum 18 inches beyond edges of hardscapes.
4. Prior to installation of pipe, mark pipe sleeve ends with vertical wood stakes extending above grade to allow field location during irrigation system installation.

C. Cutting through or jacking under new pavement is prohibited. Notify Owner's Representative upon failure to provide sleeves for resolution.

3.08 ELECTRICAL CONDUIT INSTALLATION

A. Install electrical conduit:
1. Under and through all hardscape areas
2. Above ground

B. Extend electrical conduit 18 inches beyond edges of hardscape.

3.09 ELECTRIC ZONE VALVE INSTALLATION

A. Install electric zone valves on level crushed stone base generally as shown on Construction Drawings. Do not pour stone around valves that are already installed.

B. Install all Schedule 80 PVC threaded nipples with Teflon tape, isolation valves, and/or union couplings in and out of electric zone valves as shown on details on Construction Drawings.

C. Set valves plumb with adjusting handle and all bolts, screws, and wiring accessible through valve box opening.

D. Install at sufficient depth to provide between 4-6 inches of cover from top of valve to finish grade.

E. Install specified valve box over all electric zone valves. Ensure lid is flush with final proposed grade (coordinate with Site Contractor).

F. Adjust zone valve operation after installation using flow control device on valve.

3.10 ISOLATION VALVE INSTALLATION

A. Install isolation valves per detail where indicated on Construction Drawings.

B. Install all isolation valves on level crushed stone base for operation ease with appropriate valve wrench. Do not pour stone around valves that are already installed.

C. Install specified valve box over all isolation valves. Ensure lid is flush with final proposed grade (coordinate with Site Contractor).

D. Check and tighten valve bonnet packing before valve box and backfill installation.

3.11 QUICK COUPLING VALVE INSTALLATION

A. Install quick coupling valves where indicated on Construction Drawings; generally, at ends of mainline branches and immediately downstream of well.

B. Mount mainline quick coupling valves on 1-inch diameter, 12-inch long brass swing joint assemblies and stabilizers.

C. Where mainline pressure exceeds 60 psi, install pressure regulating valves to 40 psi off quick coupling valve service tee.

3.12 WIRE INSTALLATION

A. Install wiring per local codes for less than 30-Volt service.

B. Install valve two-wire in trench alongside mainline at invert elevation. Backfill carefully to avoid any damage to wire insulation on conductors.

1. In areas of unsuitable material, use clean sand in bottom of trench before placing wire (see Excavation, Trenching, and Backfilling)
2. Minimum cover: 12-inches

C. Maintain sufficient slack for expansion, contraction and servicing. Do not install wiring tightly.

1. Provide and install additional 8 to 12 inches slack for conventional wire from decoder to valve.
2. Provide 30 inches slack between decoders for two-wire.
3. Provide sufficient length of wire in valve boxes to allow valve solenoid, splice, decoder wire, and all connections to be brought above grade for servicing.
4. Coil slack for neatness in valve box.

D. Install Decoder Cable Fuse Device as shown on Construction Drawings.

E. Provide waterproof splices at all in-ground wire connections using approved splice kits. Make splices in valve boxes and note location on Record Drawings.

F. Provide complete wiring diagram showing wire routing for connections between controller and valves as specified in Record Documents.

G. Securely store wire when not scheduled for installation.

3.13 GROUND INSTALLATION

A. Decoder Grounding (Over Earth, Not Over Structures)

1. Coordinate with on-site utility contractors and/or call 811 (Dig Safe)
2. Provide grounding for decoders – with lightning surge arrestor (as required by Manufacturer) – as shown on Construction Drawings.
3. Provide grounding per manufacturer's instructions. Where no minimum grounding requirements are specified, provide grounding every 8 decoders or 500 feet maximum.
4. Lightning/Surge Arrestor (if not included with Decoder)
   a. With waterproof splices, connect lightning arrestor red wire to site red wire and lightning arrestor black wire to site black wire. Decoder, lightning arrestor, and site two-wire may be connected in same waterproof splice as per manufacturer.
   b. With waterproof splice, connect lightning arrestor ground green wire to 8AWG solid bare copper wire. Bury bare copper wire grounding wire 12 inches minimum (or per local code) and run to grounding rod valve box.
   c. Place wired lightning arrestor (if required) neatly inside valve box.
5. Grounding Rod
   a. Prepare valve box for grounding rod installation 8 feet from all valve boxes and electrical equipment. Drive 8-foot grounding rod into earth with 6 inches minimum below valve box lid.
   b. Make Cadweld connection between bare copper wire from lightning arrestor splice to grounding rod lug.
   c. Bolt down grounding rod valve box lid.

B. Controller Grounding (To Building Ground)

1. Connect bare copper 6AWG wire to controller ground lug and connect to earth ground as directed by Electrical Contractor (example: copper pipe, building ground system). Do not create grounding loop with field decoders (different ground locations outside of influence spheres.

3.14 DECODER INSTALLATION

A. Wiring

1. With waterproof splices, connect decoder red wire to site red wire and decoder black wire to site black wire.
2. With waterproof splices, connect decoder valve leads to electric zone valve solenoid leads.
3. Place wired decoder neatly inside valve box.
4. Connect with irrigation controller and run diagnostic decoder search to link.

B. Provide grounding for decoders per manufacturer's instructions. Refer to Ground Installation section.

1. With waterproof splice, connect lightning arrestor ground green wire to 8AWG solid bare copper wire. Bury bare copper wire grounding wire 12 inches minimum (or per local code) and run to grounding rod valve box.

2. Place wired lightning arrestor (if required) neatly inside valve box.
3. Prepare 6-inch round valve box for grounding rod installation 8 feet from all valve boxes and electrical equipment. Drive 8-foot grounding rod into earth with 6 inches minimum below valve box lid.
4. Make Cadweld connection between bare copper wire from lightning arrestor splice to grounding rod lug.
5. Bolt down grounding rod valve box lid.
6. Where grounding rods cannot be driven into earth, splice all lightning arrestor green wires in series (with 8AWG green jacketed copper wire) and coordinate acceptable earth grounding with site Electrical Contractor.

3.15 SPRINKLER INSTALLATION

A. Space sprinklers as indicated on Construction Drawings.

B. Install sprinklers flush with grade on PVC swing joints as specified.

C. Flush system before installing internals, flush caps, and nozzles (see Testing and Adjustments)

D. Adjust all sprinklers after installation using flow control device on valve, do not exceed manufacturers maximum radius reduction or 75%.

3.16 DRIP IRRIGATION INSTALLATION

A. Integral Drip Emitter Tubing (Planter Beds)
1. Install in areas as shown on Construction Drawings by hand under mulch with average depth of 2 inches. Maximum 3-inch burial.
2. Install all tubing below surface, no tubing visible.
3. Install tubing on high side of plants to ensure vertical and lateral water distribution.
4. Install emitter tubing 4-inches from all planter bed edges, curbs, walls, and hardscape features.
5. Level Ground Installation
   a. Install emitter tubing in rows spaced at design spacing for level ground.
6. Slope Installation
   a. Install emitter tubing in rows spaced at design spacing for top 2/3 of slope.
   b. Install emitter tubing in rows spaced at 1.5 times design spacing for bottom 1/3 of slope.
   c. Orient rows parallel to slope.
7. For every 4 feet of elevation difference within drip zone, install check valve on supply header.
8. Provide pressure regulation as designed.
9. Secure emitter tubing with stakes every 5 feet to prevent shifting from compaction, slopes, and general operation.
10. Install Automatic Flush Valves on farthest ends of PVC exhaust headers and at lowest elevation; generally, where shown on Construction Drawings.

B. Tree Stake Drip Irrigation (Point Source Drip Irrigation)

1. Use PE Supply and Exhaust Header pipes. Use manufacturer pierced barbed fittings for connection to drip tubing.
2. Install 0.9 gal/hour emitter drip tubing generally as shown on Construction Drawings by hand directly on top of root ball:
   a. One (1) Inner Drip Tubing Rings centered on trunk at midpoint to root ball edge
   b. One (1) Outer Drip Tubing Ring centered on trunk just outside root ball edge
   c. Install blank Drip Tubing Ring between Inner and Outer Drip Tubing Rings
3. Install piercing barb emitters within blank tubing with barbed connections outward. Install two (2) emitters per tree. Flow rates are indicated on Construction Drawings.
4. With care (air spade or moistening root ball), insert Deep Drip Stakes through root ball between truck and canopy of tree. Install two (2) 14-inch stakes for each tree. Expose only top of cap at-grade. Take care so as to not drive stake through main root tap—stay within root ball perimeter.
5. Run ¼-inch Distribution Tubing from each barbed end emitter on blank drip tubing. Provide sufficient slack (6 inches) for ease of maintenance. Install diffuser cap at Drip Stake end of ¼ inch Distribution Tubing. Place diffuser cap end and tubing inside Drip Stake through inlet and seal Drip Stake Cap. Conceal distribution Tubing below ground surface.
6. For every 8.5 feet of elevation difference, install check valve on supply header.
7. Ensure all in-line tubing includes pressure regulation to 30 psi for uniformity.
8. Secure emitter tubing with stakes every 5 feet to prevent shifting from compaction, slopes, and general operation.
9. Install automatic flush valves on end of exhaust header at lowest elevation, and at furthest point from Electric Zone Valves, generally where shown on Construction Drawings.

C. Electric Zone Valves (Drip Zone Kits)

1. Install Electric Zone Valves as shown on details within appropriately sized valve boxes (see below).
2. Provide separate feeds for Structural Soil and Tree Root Balls from same electric Drip Zone Kit. Provide isolation gate valves at each branch prior to structural soil in landscaped area for servicing and to reduce irrigation as needed after establishment.
3. Wire and program valves to Irrigation Controller.

3.17 AUTOMATIC IRRIGATION CONTROLLER INSTALLATION

A. Controller

1. Install controller at location shown on Construction Drawings.
   a. Program “Cycle-Soak” feature for all zones with sloped or poorly draining soils.
   b. Install and calibrate all sensors as per manufacturer instructions.
   c. Program controller and irrigation zones generally as shown on Construction Drawings, considering:

1) Sun vs. Shade
2) Lawn vs. Plantings
3) Heavy vs. Light Soils
4) Use Irrigation Plans provided for Recommended Quantity and Assignment

2. Using licensed electrical, wire controller to 120-Volt, 20-Amp electrical supply provided by Electrical Contractor.
3. Provide keys to Owner after final walkthrough.

B. Rain and Weather Sensors

1. Install wireless rain or weather sensor with direct overhead exposure to atmospheric conditions and not in contact with overhead irrigation.
2. Install wireless rain or weather sensor within limits of sensor receiver adjacent to irrigation controller. Confirm wireless connectivity range prior to final installation.

C. Flow Sensor

1. Install Flow Sensor Indoors where shown on Construction Drawings.
2. Provide straight pipe for 2-Inch Flow Sensor to reduce turbulence:
   a. Upstream: 20 inches (10 times pipe diameter)
   b. Downstream: 10 inches (5 times pipe diameter)
3. Wire Flow Sensor to Decoder and Automatic Irrigation Controller as specified with waterproof connectors. Do not make extra splices between Controller and Flow Sensor. Ground Sensor Decoder as required by manufacturer to building ground where possible.

D. Master Valve

1. Install Master Valve Indoors where shown on Construction Drawings.
2. Wire Master Valve to Decoder and Automatic Irrigation Controller as specified with waterproof connectors. Do not make extra splices between Controller and Master Valve. Ground Decoder as required by manufacturer to building ground where possible.

E. Grounding

1. Coordinate with Electrical Contractor for acceptable indoor ground location (if available).

3.18 VALVE BOX INSTALLATION

A. Furnish and install valve boxes as per valve schedule above for each valve, splice, or sensor.

B. Install valve boxes on minimum 4-inches crushed stone base. Pouring stone into valve box after installation is not acceptable.

C. Install valve boxes with finish lid elevation flush with grade, unless otherwise noted on Construction Drawings.

D. Provide level brick supports beneath valve boxes.

1. For square/rectangular boxes, provide four (4) supports - one at each corner.
2. For round boxes, provide three (3) supports equally spaced.

3.19 TESTING AND ADJUSTMENTS

A. Include all testing and adjustments in submitted bid price.

B. System Flushing:

1. Open electric zone valves and drip flush valves and flush out irrigation system under full head of water before installing sprinkler internals, flush caps, and nozzles.
2. Flush entire irrigation system after complete installation.
3. Clear and replace clogged nozzles after completion of irrigation system.

C. Testing:

1. Test all pipe and valves for leaks at operating pressure. Repair all leaks and retest until leaks are remedied.
2. Perform coverage test with Owner's Representative present. Operate electric zone valves for five (5) minutes minimum during coverage test. Readjust sprinkler nozzles and head locations (as necessary) to attain proper coverage. Replace any equipment that does not meet specified standards.
3. After testing, clean all equipment of debris during installation.

D. Adjust drip irrigation, sprinkler heads and valve boxes as necessary for mowing and landscaping.

E. Throughout guarantee period, adjust sprinklers and ensure coverage due to settlement and landscaping operations.

3.20 RECORD DOCUMENTS

A. Record (As-Built) Drawings

1. Maintain and update Record Drawings with red-line markings as installation progresses, including locations of:
   a. Sprinklers and descriptions (nozzle, pop-up height, and type)
   b. Valve Boxes and descriptions (valve type, zone numbers, splice)
   c. All equipment installed with distinct symbols.
   d. Pipe routing and tees.
   e. Wire routing and splices.
2. Reference locations of installed equipment (valve, controller, sensors) s by two permanent locations (swing ties) or GPS.
3. Make all notes legible as work progresses. Add distinct symbols denoting location for any new equipment added.
4. Document any changes from original Construction Drawings.
5. Record Drawings are used as basis of payment for work completed. Provide copies of red-lined set to Owner's Representative along with payment request.

B. Record Documents

1. Always keep Record Documents on-site. Maintain record of these milestones as installation progresses:
   a. Plumbing and Electrical permits (state whether or not required)
   b. Materials Approved and approval date
   c. Pressure Test results, testing personnel and testing date.
   d. Materials delivered, Accepted, and Installed by whom and date.
   e. Field Communications and Requests for Information (RFI)

C. Prior to final punchlist, provide complete electronic and hard copy files of Record Drawings and Documents to Owner's Representative as part of installation completion.

3.21 OPERATION AND MAINTENANCE

A. General

1. Include with bid price up to four (4) hours of irrigation system overview and instruction with Owner and/or Owner's Representative.

B. Operation and Maintenance Manual

1. Provide three (3) hard cover binders titled "Doherty Memorial High School Irrigation System" prior to application for acceptance and final payment.

2. Operation and Maintenance Manual includes, but not be limited to:
   a. Title Page and Table of Contents
   b. One-Paragraph Written Description of Irrigation System
   c. Manufacturers' Data and Cut Sheets of Equipment, including:
      1) Copies of all approved submittals
      2) Wire resistance readings to each electric valve at completion (for future troubleshooting)
      3) Recommended operating settings
      4) Recommended maintenance schedule
      5) Name, address, and telephone number of installer (for repairs, spring startup, and winterization during 1-year guarantee period)
      6) Irrigation program for periods without rain and recommended settings including, zone run time, days per week, cycle-soak, and rain sensor suspension.
   d. Winterization and Spring Startup Instructions (after 1-year guarantee period)
   e. Guarantee Data
   f. Pockets with Folded Plans of:
      1) Original Design Drawing
      2) Final Record Drawing
      3) Controller Valve and Wiring System Diagram Drawing

3.22 SITE CLEANUP

A. Remove all unused materials and equipment from site safely and efficiently. Dispose of all unused materials legally - including construction debris and trash.

B. Adjust ground, compact, and re-plant around irrigation sprinkler heads and trenches as necessary for proper angle and elevation.

C. Fill all depressions, erosion rills, and tire tracks with proper planting soil mix to ensure site drainage.

3.23 FINAL OWNER ACCEPTANCE

A. Final Owner Acceptance of Irrigation System is predicated on:

1. Complete system installation, adjustment, testing, and instructional overview.
2. Submission of Operation and Maintenance Manuals to Owner's Representative.
3. Proper Programming of Automatic Irrigation Controller.
4. Completed and approved all punchlist items.

B. Start of 1-year guarantee period begins on date of Owner's written notice of final acceptance.

END OF SECTION

Section 32 91 13. 16

MULCH

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01, GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.2 DESCRIPTION OF WORK

A. Provide all equipment and materials, and do all work necessary to construct the mulch surfacing in planting areas as shown, as indicated on the Drawings and as specified.

1.3 RELATED SECTIONS

A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that directly relate to work of this Section include, but are not limited to:

1. Section 31 20 00, EARTH MOVING.
2. Section 32 80 00, IRRIGATION SYSTEM.
3. Section 32 91 19, LANDSCAPE GRADING.
4. Section 32 93 00, TREES, PLANTS AND GROUND COVERS.

1.4 REFERENCES

A. Comply with applicable requirements of the following standards. Where these standards conflict with other specified requirements, the most restrictive shall govern:

1. American Society for Testing and Materials (ASTM):

   D 1557 Moisture-Density Relations of Soils and Soil Aggregate Mixtures Using 10-lb. (4.54-kg) Rammer and 18-in. (475-mm) Drop

2. Commonwealth of Massachusetts Highway Department (MHD):

   Standard Specifications for Highways and Bridges

1.5 SUBMITTALS

A. Samples: The following samples shall be submitted:

1. 2 lb. sample of crushed stone shall be submitted for the Architect's approval of material gradation. Color to be native/tan color range.
2. A one gallon sample of wood bark mulch shall be submitted for the Architect’s approval.
3. Steel edge: 12 in. long section with one stake

B. Manufacturer’s Product Data: Manufacturer’s product data shall be submitted of the following materials:

1. Steel edge and stake

PART 2 - PRODUCTS

2.1 CRUSHED NATIVE STONE SURFACING MULCH

A. Planting areas: Crushed native stone for surfacing shall be in the tan range, 3/8"-½" crushed, washed, stone meeting the following gradation:

Sieve Size	% Passing by Weight
1/4 in.	100
3/8 in.	80 - 100
No.4	15 - 85
No. 8	0 - 5
No. 200	<1

2.2 WOOD BARK MULCH

A. Mulch shall be a 100% fine-shredded pine mulch of uniform size and free from rot, leaves, twigs, debris, stones, or any material harmful to plant growth. Bark shall have been shredded and stockpiled no less than six months and no more than two years before use. No chunks three inches or more in size and thicker than 1/4 in. shall be left on site. Bark mulch shall contain no dye.

2.3 EDGING

A. Heavy Duty Edging shall be one of the following:

1. Cleanline XL Edging: by Permaloc Corporation, Holland MI 49424, telephone (800) 356-9660,(616) 399-9600,
2. Heavy Duty Duraedge by JD Russell Company, PO Box 183471, Shelby Township, MI 48318 p: 586.254.8500; www.jdrussell.com;
3. Border Guard by Border Concepts, 7621 Little Ave, Suite 426, Charlotte, NC 28226, p: 800.845.3343, www.borderconcepts.com.

B. Edging shall have the following properties:

1. Thickness: min 3/16 inch
2. Length: Min 10'sections.
3. Depth: min 6"
4. Connection Method: Section ends shall splice together with a horizontal 0.060 inch (1.52 mm) thick x 1 inch (25 mm) wide x 4 inches (102 mm) long aluminum sliding connector.
5. Sections shall have loops on side of section to receive stakes.
6. Stake: min.12" (305mm) Stakes to interlock into section loops.
7. Finish color: Black. Contractor to submit samples for approval. Paint finish shall comply with AAMA 2603 for electrostatically baked on paint.

2.4 PRE-EMERGENT HERBICIDE

A. Herbicide shall be Pollinator Friendly, Atrazine or Prodiamine based Herbicide, pre-emergent grassy and selected broadleaf weed control for ornamental plants, nursery stock and ground covers. Submit EPA information and SDS information for approval.

PART 3 - EXECUTION

3.1 GRADING

A. Areas to receive crushed native stone surfacing/bark mulch will be compacted and brought to subgrade elevation under Section 31 20 00, EARTH MOVING before work of this section is performed. Final fine grading, furnishing and installing crushed native stone surfacing/bark mulch and compaction of these materials as required to form a uniform, accurate, aggregate at required elevations and to required lines, shall be done under this Section.

B. Existing subgrade material which will not readily compact as required shall be removed and replaced with satisfactory materials. Additional materials needed to bring subgrade to required line and grade and to replace unsuitable material removed shall be material conforming to this Section.

C. Subgrade of areas to receive crushed native stone surfacing/bark mulch shall be recompacted as required to bring top 4 in. of material immediately below to a compaction of at least 90% of maximum density, as determined by ASTM D 1557. Subgrade compaction shall extend for a distance of at least 1 ft. beyond proposed edge of crushed native stone surfacing.

D. Excavation required in subgrade shall be completed before fine grading and final compaction of subgrade are performed. Where excavation must be performed in completed subgrade, subsequent backfill and compaction shall be performed as directed by the Architect as specified in Section 31 20 00, EARTH MOVING and Section 32 93 00 TREES, PLANTS AND GROUNDCOVERS. Completed subgrade after filling such areas shall be uniformly and properly graded.

E. Areas being graded or compacted shall be kept shaped and drained during construction. Ruts greater than or equal to 1 in. deep in subgrade, shall be graded out, reshaped as required, and recompacted before placing crushed native stone surfacing.

F. Materials shall not be stored or stockpiled on subgrade.

G. Disposal of debris and other material excavated and/or stripped under this section, and material unsuitable for or in excess of requirements for completing work of this section shall be disposed of off-site.

3.2 EDGING

A. Edging shall be installed at locations indicated on the Drawings. Where required, edging shall be cut square and accurately to required length.

1. Steel edging shall be securely staked in required position. Stakes shall be driven every 30 in. o.c. along length of edging.

2. Adjacent lengths of edging shall overlap or be spliced together with manufacturer's standard splicer unit.
3. Edging shall be set plumb and vertical at required line and grade. Straights sections shall not be wavy; curved sections shall be smooth and shall have no kinks or sharp bends.

3.3 MULCH INSTALLATION - GENERAL

A. Mulches shall be installed only after excavation, construction and planting or any other work which might injure it has been completed. Damage caused during construction shall be repaired before acceptance.

B. Finished elevation of all mulch shall be minimum ½" to 1" below adjoining surface(s) after watering. Add or remove mulch as necessary to achieve the final grade.

C. All mulch shall be installed at depths specified in the drawings. If excess depth is measured, mulch will need to be removed, subgrade adjusted, and mulch reinstalled.

D. Mulch shall not be installed over tree root flares.

3.4 CRUSHED NATIVE STONE MULCH

A. Crushed native stone mulch shall be installed in planting areas as shown on the construction Drawings to a depth as indicated in the details.

B. Water shall be added to crushed native stone mulch as required to remove any fines that may have settled during installation.

END OF SECTION

Section 32 91 19

LANDSCAPE GRADING

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01, GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.2 DESCRIPTION OF WORK

A. Provide all equipment and materials, and do all work necessary to complete the landscape grading as indicated on the Drawings and as specified.

1.3 RELATED SECTIONS

A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that directly relate to work of this Section include, but are not limited to:

1. Section 31 20 00, EARTHWORK.
2. Section 32 93 00, TREES, PLANTS, AND GROUNDCOVERS.

1.4 REFERENCES

A. Comply with applicable requirements of the following standards. Where these standards conflict with other specified requirements, the most restrictive shall govern:

1. American Society for Testing and Materials (ASTM):

   D 698 Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ (6000kN- m/m³))

   D 1556 Density of Soil in Place by the Sand-Cone Method

   D 2167 Density and Unit Weight of Soil In Place by the Rubber-Balloon Method

2. Commonwealth of Massachusetts Highway Department (MHD):

   Standard Specifications for Highways and Bridges

1.5 EXISTING CONDITIONS

A. By submitting a bid, the Contractor affirms that he has carefully examined the site and all conditions affecting work under this Section. No claim for additional costs will be allowed because of lack of knowledge of existing conditions.

1.6 QUALITY CONTROL

A. The Architect reserves the right to perform on-site observation during the grading operations. The observations may include, but not be limited to the following:

1. Observation of subgrade preparation for slab-on-grade and paved areas.
2. Observation of rough and finish grading operations.

B. All grade breaks shall be staked with grade stakes at each end, any change of direction, and at 20' centers along the length for Architect's review during grading operations.

C. Perform field density tests in accordance with ASTM D 1556 or ASTM D 2167.
   1. Make at least one field density test of the subgrade for every 2000 sq. ft. of paved area, but in no case less than three tests.
   2. In each compacted fill layer, make one field density test for every 2000 sq. ft. of overlaying paved area, but in no case less than three tests.
   3. Make at least one field density test of the planting soil for every 2000 sq. ft. of plant bed area, but in no case less than three tests.
   4. Make at least one field density test of the planting soil for every 2000 sq. ft. of lawn area, but in no case less than three tests.

D. If, in the opinion of the Architect, based on reports of the testing service and inspection, the subgrade or fills which have been placed are below the specified density, additional compaction and testing will be required until satisfactory results are obtained.
   1. The results of density tests of soil-in-place will be considered satisfactory if the average of any four consecutive density tests which may be selected are in each instance equal to or greater than the specified density, and if not more than one density test out of five has a value more than 2% below the required density.

E. The Architect's presence does not include supervision or direction of the actual work by the Contractor, his employees, or agents. Neither the presence of the Landscape Architect, nor any observations and testing performed by him shall excuse the Contractor from defects discovered in his work.

1.7 PROTECTION OF EXISTING STRUCTURES AND UTILITIES

A. The work shall be executed in such manner as to prevent any damage to adjacent property and any other property and existing improvements such as, but not limited to: streets, curbs, paving, utility lines and structures, monuments, bench marks and other public and private property.

B. In case of any damage or injury caused in the performance of the grading work, the Contractor shall, at his own expense, make good such damage or injury to the satisfaction of, and without cost to the Owner. Existing roads, sidewalks, and curbs damaged during the grading work shall be repaired or replaced to their original condition at the completion of operations. The Contractor shall replace, at his own cost, existing bench marks, monuments, and other reference points which are disturbed or destroyed.

1.8 COORDINATION

A. Prior to start of grading operations, the Contractor shall arrange an on-site meeting with the Architect for the purpose of establishing Contractor's schedule of operations and scheduling inspection procedures and requirements.

B. As construction proceeds, the Contractor shall be responsible for notifying the Architect prior to start of grading operations requiring inspection and/or testing.

C. The Contractor shall be responsible for obtaining test samples of soil materials proposed to be used and transporting them to the site sufficiently in advance of time planned for use of these materials for testing of materials to be completed. Use of these proposed materials by the Contractor prior to testing and approval or rejection, shall be at the Contractor's risk.

PART 2 - PRODUCTS

2.1 SOURCE OF MATERIALS

A. Material shall be obtained from required on-site excavation, to the extent that suitable material is available, and from off-site sources, to the extent that suitable material is not available from on-site excavation.

B. Refer to Section 329200 for preparation and placement of planting soils.

PART 3 - EXECUTION

3.1 GRADING

A. Refer to Section 312000, EARTHWORK for required levels of subgrade compaction at paved areas.

1. Unless otherwise indicated, scarified subgrade in landscape areas shall be compacted to 86% - 88% compaction ASTM D698 Standard Proctor.
2. Planting Soil – Planting Pits and Beds: shall be spread in lifts not greater than 6 inches and compacted to a density between 82 and 86 percent Standard Proctor Maximum Dry Density.
3. Planting Soil - Lawn Areas: shall be spread over the area and shall be compressed to a density of 86 to 88% Standard Proctor maximum dry density. No vibratory compaction of the subgrade or the planting medium shall take place. No rubber-tired equipment or heavy equipment except for a small bulldozer shall pass over soils after they have been loosened or planting medium spread.

3.2 GRADING - GENERAL

A. Uniformly grade areas within the limits of site grading under this section, including adjacent transition areas. Smooth finished surfaces within specified tolerances, and between points where elevations are shown, or between such points and existing grades.

B. The degree of finish required will be that ordinarily obtainable from either blade-grader or scraper operations.

1. Ditches: Finish ditches to ensure proper flow and drainage. Conduct final rolling operations to produce a hard, uniform, and smooth cross-section.
2. Grade Breaks located on the plans indicate crisp transitions, not blended or rounded edges. These should be clean, sharp, and uniform in line and curve as indicated on the plans

3.3 ROUGH GRADING

A. General: Rough grading shall include the shaping, trimming, rolling and refinishing of all surfaces of the subbase, shoulders, earth embankments and the preparation of grades as shown on the Drawings. The grade of shoulders and sloped areas may be done by machine methods.

B. Do all cutting, filling and grading to lines and grades indicated on the Drawings. Grade evenly to within the dimensions required for grades shown on the Drawings and specified herein. No stones larger than 4 in. shall be placed in upper 6 in. of fill. Fill shall be left in compacted state at the end of work day and sloped to drain.

1. Architect may make such adjustments in grades and alignments as are found necessary to avoid special conditions encountered.
2. Provide a smooth transition between adjacent existing grades and new grades.
3. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.

C. Site Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:

1. Lawn or Unpaved Areas: Plus or minus 1 inch (25 mm).
2. Walks: Plus or minus 1 inch (25 mm).
3. Pavements: Plus or minus 1/2 inch (13 mm).
4. Up to 2 in. in 10 ft. – 0 in. tolerance shall be permitted on slopes provided the slopes are uniform in appearance and without any abrupt changes.

D. Traffic of men and equipment across soil subgrade areas shall be prohibited following excavation to the required lines and grades.

3.4 FINE GRADING

A. General: Uniformly grade areas to a smooth surface, free from irregular surface change changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.

1. Provide a smooth transition between adjacent existing grades and new grades.
2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.

B. Finish Grading:

1. Lawn or Unpaved Areas: Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Grade to within plus or minus 1/2 inch (13 mm) of finish elevation. Roll and rake, remove ridges, and fill depressions to meet finish grades. Limit finish grading to areas that can be planted in the immediate future.
2. Walks: Shape the surface of areas under walks to line, grade and cross-section, with the finish surface not more than 0.00 ft. above or 0.10 ft. below the required subgrade elevation, compacted as specified, and graded to prevent ponding of water after rains.

C. Pavements: Shape the surface of the areas under pavement to line, grade and cross- section, with the finish surface not more than 1/2 in. above or below the required subgrade elevation, compacted as specified, and graded to prevent ponding of water after rains. Include such operations as plowing, discing, and any moisture or aerating required to provide the optimum moisture content for compaction. Fill low areas resulting from removal of unsatisfactory soil materials, obstructions, and other deleterious materials, using satisfactory soil material. Shape to line, grade, and cross- section as shown on the Drawings.

3.5 MAINTENANCE

A. Protect newly graded areas from traffic and erosion. Keep free of trash and debris.

B. Repair and re-establish grades in settled, eroded, and rutted areas to the specified tolerances.

C. Where completed compacted areas are disturbed by subsequent construction operations or adverse weather, scarify the surface, re-shape, and compact to the required density prior to further construction.

3.6 DISPOSAL OF EXCESS AND WASTE MATERIALS

A. Remove waste materials, including excavated material classified as unsatisfactory soil material, trash and debris, and dispose of it legally off the Owner's property.

END OF SECTION

Section 32 92 00

LAWNS AND GRASSES

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01, GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.2 DESCRIPTION OF WORK

A. Provide all materials and equipment, and do all work required to complete the seeding and sodding of lawns, as indicated on the Drawings and as specified.

1.3 RELATED SECTIONS

A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that directly relate to work of this Section include, but are not limited to:

1. Section 31 20 00, EARTH MOVING
2. Section 32 80 00, IRRIGATION SYSTEM
3. Section 32 91 16.16, MULCH.
4. Section 32 91 19, LANDSCAPE GRADING
5. Section 32 93 00, TREES, PLANTS AND GROUND COVERS.

1.4 REFERENCES

A. Comply with applicable requirements of the following standards. Where these standards conflict with other specified requirements, the most restrictive shall govern:

1. American Society for Testing and Materials (ASTM):

C 136	Sieve Analysis of Fine and Coarse Aggregates
D 422	Particle-Size Analysis of Soils
E 11	Wire-Cloth Sieves for Testing Purposes

1.5 SUBMITTALS

A. Samples: The following samples shall be submitted:

1.

Material	Quantity (lb.)
Seed, each mix	1

B. Manufacturer's Product Data: Manufacturer's product data shall be submitted for the following materials:

1. Cellulose fiber mulch

C. Certificates: Labels from the manufacturer's container certifying that the product meets the specified requirements shall be submitted for the following materials:

1. Grass seed
2. Sod: Seed and growing medium information

1.6 DELIVERY, STORAGE, AND HANDLING

A. Digging Sod:
1. Sod shall not be dug at the nursery or approved source until ready to transport sod to the site of the work or acceptable storage location.
2. Before stripping, sod shall be mowed at a uniform height of 2 in.
3. Cut sod to specified thickness and to standard width and length desired.

B. Transportation of Sod:
1. Sod transported to the Project in open vehicles shall be covered with tarpaulins or other suitable covers securely fastened to the body of the vehicle to prevent injury. Closed vehicles shall be adequately ventilated to prevent overheating of the sod.
2. Evidence of inadequate protection following the digging, carelessness while in transit, or improper handling shall be cause for rejection.
3. Sod shall be kept moist, fresh, and protected at all times. Such protection shall encompass the entire period during which the sod is in transit, being handled, or are in temporary storage.
4. Upon arrival at the temporary storage location or the site of the work, sod material shall be inspected for proper shipping procedures. Should the sod be dried out, the Architect will reject the sod. When sod has been rejected, the Contractor shall at once remove it from the area of the work and replace it with acceptable material.
5. Unless otherwise authorized by the Architect, the Contractor shall notify the Architect at least two working days in advance of the anticipated delivery date of sod material. Certificate of Inspection when required shall accompany each shipment.

C. Handling and Storage of Sod:
1. Sod material shall be handled with extreme care to avoid breaking or tearing strips.
2. Sod shall not be stored for longer than 30 hours prior to installation. Sod shall be stored in a compact group and shall be kept moist. Sod shall be prevented from freezing.
3. Sod that has been damaged by poor handling or improper storage will be rejected by the Architect.

D. Deliver seed in original sealed containers, labeled with analysis of seed mixture, percentage of pure seed, year of production, net weight, date of packaging, location of packaging, and name of seed grower. Damaged packages will not be accepted.

E. Seed shall be stored under cool and dry conditions so that the endophytic seed in the mixture is capable of maintaining a high level of endophytes

F. Deliver fertilizer in sealed waterproof bags, printed with manufacturer's name, weight, and guaranteed analysis.

1.7 PLANTING SEASON

A. Planting season shall be as follows:

Material	Planting Season Spring	Fall
Seeding and sodding	3/15 to 5/15	8/15 to 10/15

B. Planting shall only be performed when weather and soil conditions are suitable for planting the material specified in accordance with locally accepted practice.

C. Planting season may be extended with the written permission of the Architect.

1.8 ACCEPTANCE

A. Acceptance:

1. The Architect will inspect all work for Substantial Completion upon written request of the Contractor. The request shall be received at least ten calendar days before the anticipated date of inspection.
2. Acceptance of material by the Architect will be for general conformance to specified requirements, and shall not relieve the Contractor of responsibility for full conformance to the Contract Documents.
3. Upon completion and reinspection of all repairs or renewals necessary in the judgement of the Architect, the Architect will recommend to the Owner that the work of this Section be accepted.

B. Sod and seed areas will be accepted when in compliance with all the following conditions:

1. Roots are thoroughly knit to the soil;
2. Absence of visible joints (sodded areas);
3. All areas show a uniform stand of specified grass in healthy condition;
4. At least 60 days have elapsed since the completion of work under this Section.

PART 2 - PRODUCTS

2.1 GENERAL

A. Materials shall be extracted or recovered and manufactured from within 500 miles of project site.

2.2 SEED

A. Seed mixture: To be a Certified No-Mow Fine Fescue with Annual Rye seed mix. Standard grade seed of the most recent season's crop. Seed shall be dry and free of mold. Seed shall be inoculated with endophytes. Seed mixture shall be as follows:

SEED MIX NAME OF SEEED	% BY WEIGHT IN MIXTURE
Festuca longifolia Hard Fescue	25
Festuca rubra var. rubra Creeping Red Fescue	20
Festuca rubra var. commutate Chewing Fescue	20
Festuca ovina Sheep Fescue	25
Annual Ryegrass	10

2.3 SOD LAWN

A. Certified Turfgrass Sod: Superior sod grown from certified, high quality seed of known origin or from plantings of certified grass seedlings or stolons. It shall be inspected by the certification agency of the state in which it is grown to assure satisfactory genetic identity and purity, overall high quality and freedom from noxious weeds as well as excessive quantities of other crop and weedy plants at time of harvest. All seed or original plant material in mixture must be certified. Turfgrass sod shall meet the published state standards for certification.

1. Sod shall be a mixture of four or five current and improved bluegrass varieties found in the top 25% of the NTEP (National Turfgrass Evaluation Proceedings), with last two tests spanning over 8 years. Mixture shall contain approximately equal proportions of each hybrid component.

B. Sod shall be nursery grown on cultivated mineral agricultural soils. Sod shall have been mowed regularly and carefully, and otherwise maintained from planting to harvest.

C. Thickness of Cut: Sod shall be machine cut at a uniform soil thickness of 5/8 in., plus or minus 1/4 in., at the time of cutting. Measurement for thickness shall exclude top growth and thatch.

D. Strip Size: Individual pieces of sod shall be cut to the supplier's standard width and length. Maximum allowable deviation from standard widths and lengths shall be plus or minus 1/2 in. on width, and plus or minus 5% on length. Broken strips and torn and uneven ends will not be acceptable.

E. Strength of Sod Strips: Standard size sections of sod shall be strong enough to support their own weight and retain their size and shape if suspended vertically when grasped in the upper 10% of the section.

F. Moisture Content: Sod shall not be harvested or transplanted when moisture content (excessively dry or wet) may adversely affect its survival.

G. Time Limitations: Sod shall be harvested, delivered, and transplanted within a 36 hour period unless a suitable preservation method is approved prior to delivery.

Sod not transplanted within this period shall be inspected and approved by the Architect prior to its installation.

H. Thatch: Sod shall be relatively free of thatch. A maximum of 1/2 in. (uncompressed) thatch will be permitted.

I. Diseases, Nematodes, and Insects: Sod shall be free of diseases, nematodes, and soil- borne insects. State Nursery and Plant Materials Laws require that all sod be inspected and approved for sale. The inspection and approval must be made by the State Agricultural Department, Office of the State Entomologist.

J. Weeds: Sod shall be free of objectionable grassy and broad leaf weeds. Turfgrass sod shall be considered free of such weeds if less than five such plants are found per 100 sq. ft. of area.

1. Turfgrass sod shall not be acceptable if it contains any of the following weeds: common bermudagrass (wiregrass), quackgrass, johnsongrass, poison ivy, nutsedge, nimblewill, Canada thistle, bindweed, bentgrass, wild garlic, ground ivy, perennial sorrel and bromegrass.

2.4 FESCUE SOD

A. Fescue sod to be Certified No Mow Fine Fescue Sod: Superior sod grown from certified, high quality seed of known origin or from plantings of certified grass seedlings or stolons. It shall be inspected by the certification agency of the state in which it is grown to assure satisfactory genetic identity and purity, overall high quality and freedom from noxious weeds as well as excessive quantities of other crop and weedy plants at time of harvest. All seed or original plant material in mixture must be certified. No Mow Fescue sod shall meet the published state standards for certification.

1. Sod shall be a mixture of three fescues: creeping red, chewing and hard fescues adapted to both mown and unmown conditions. Shall be grown in a controlled environment free of weeds, disease and insect infestations.

B. Sod shall be nursery grown on cultivated mineral agricultural soils. Prior to harvesting No Mow fescue sod shall be mown to a height of 2” for shipment.

C. Thickness of Cut: Sod shall be machine cut at a uniform soil thickness of 3/4 in., plus or minus 1/4 in., plus top growth at the time of cutting.

D. Strip Size: Individual pieces of sod shall be cut to the supplier's standard width and length typically 24” wide x 48” long. Maximum allowable deviation from standard widths and lengths shall be plus or minus 1/2 in. on width, and plus or minus 5% on length. Broken strips and torn and uneven ends will not be acceptable.

E. Strength of Sod Strips: Standard size sections of sod shall be strong enough to support their own weight and retain their size and shape if suspended vertically when grasped in the upper 10% of the section.

F. Moisture Content: Sod shall not be harvested or transplanted when moisture content (excessively dry or wet) may adversely affect its survival.

G. Time Limitations: Sod shall be harvested, delivered, and transplanted within a 36 hour period unless a suitable preservation method is approved prior to delivery.

Sod not transplanted within this period shall be inspected and approved by the Architect prior to its installation.

H. Thatch: Sod shall be relatively free of thatch. A maximum of 1/2 in. (uncompressed) thatch will be permitted.

I. Diseases, Nematodes, and Insects: Sod shall be free of diseases, nematodes, and soil- borne insects. State Nursery and Plant Materials Laws require that all sod be inspected and approved for sale. The inspection and approval must be made by the State Agricultural Department, Office of the State Entomologist.

J. Weeds: Sod shall be free of objectionable grassy and broad leaf weeds. No Mow Fescue sod shall be considered free of such weeds if less than five such plants are found per 100 sq. ft. of area.

1. No Mow Fescue sod shall not be acceptable if it contains any of the following weeds: common bermudagrass (wiregrass), quackgrass, johnsongrass, poison ivy, nutsedge, nimblewill, Canada thistle, bindweed, bentgrass, wild garlic, ground ivy, perennial sorrel and bromegrass.

2.5 SOD FARM GROWING MEDIUM

A. Sod farm growing medium shall be as specified in Section 329300, TREES, PLANTS AND GROUND COVERS.

2.6 PLANTING SOIL

A. Planting soil shall be as specified in Section 329300, TREES, PLANTS AND GROUND COVERS.

2.7 WATER

A. Water shall be suitable for irrigation and free from ingredients harmful to seeded or sodded areas.

2.8 SOIL AMENDMENTS

A. Soil amendments shall be as specified in Section 329300, TREES, PLANTS AND GROUND COVERS.

2.9 CELLULOSE FIBER MULCH

A. Cellulose fiber mulch shall be composed of virgin wood, contain a green color additive, be weed free, and non-polluting, containing no germination or growth - inhibiting factors, similar to Hydro Mulch, manufactured by Conwed Corporation, St. Paul, Minnesota 55113.

2.10 WEED CONTROL

A. Weed control for stockpiled topsoil shall be a non-selective weed killer for control of grassy and broadleaf weeds; weed control shall have short residual, allowing seeding and sodding operations to occur within 7 days of application.

2.11 FILTER FABRIC

A. Filter fabric shall be a non-woven, 5 ounce weight polypropylene fabric. Approved fabrics are as follows:

1. Mirafi 140N, manufactured by Tencate, 365 South Holland Drive, Pendergrass, GA 30567; Tel 800 685 9990; Tel 706 693 2226; Fax 706 693 4400; www.mirafi.com .
2. Westward Landscape fabric as available from DeWitt, 573.471.6715, dewittcompany.com
3. LM 600 NT landscape fabric as available from L&M Supply, 1800 Springhead Church Road, Willacoochee, GA 31650, landmsupplyco.com.

2.12 LANDSCAPE EDGING

A. Landscape Edging shall be per Section 32 91 16.16, MULCH.

PART 3 - EXECUTION

3.1 PREPARATION OF SUBGRADE

A. Subgrade shall be examined and prepared in accordance with Section 329300, TREES, PLANTS AND GROUNDCOVERS.

3.2 PLACING AND SPREADING PLANTING SOIL

A. Planting soil shall not be spread until it is possible to follow immediately or within 24 hours with seeding and sodding operations. If planting soil is spread prior to this time it shall be cultivated to loosen soil prior to seeding and sodding.

B. Placing and spreading planting soil shall be performed as specified in Section 329300, TREES, PLANTS AND GROUNDCOVERS.

3.3 APPLICATION OF SOIL AMENDMENTS

A. Fertilizer and conditioners shall be applied as specified in Section 329300, TREES, PLANTS AND GROUNDCOVERS.

3.4 FINISH GRADING

A. Contractor shall set grade lines for Landscape Architect’s review and approval. All work per Section 329119 LANDSCAPE GRADING.

3.5 SEED APPLICATION

A. Seed shall be applied in two applications; first shall be by mechanical spreader; second shall be by hydroseeding method as specified below.

B. First Application: Seed shall be broadcast by means of an approved mechanical spreader, to give a uniform application at rates recommended by seed supplier.

1. Seed shall be applied in two equal applications for uniform coverage; direction of travel of spreader for second pass shall be perpendicular to that of the first pass. Seeding shall not be done when it is raining or snowing, or when wind velocity exceeds 5 mph.

2. Following seeding the area shall be lightly raked to mingle seed with top 1/8 to 1/4 in. of soil. Area shall then be fine graded. Stones and other debris greater than 1 in. in any dimension which are visible on surface shall be removed.

C. Following seeding and raking, entire area shall be rolled with a hand roller having a weight of 60 to 90 lb./ft. of width, and a minimum diameter of 2 ft. Entire area shall then be watered by use of lawn sprinklers, or other approved means. Initial watering shall continue until the equivalent of a 2 in. depth of water has been applied to entire seeded surface, at a rate which will not dislodge the seed. Watering shall be repeated thereafter as frequently as required to prevent drying of the surface, until the grass attains an average height of 1/4 in. Watering methods and apparatus which may cause erosion of the surface shall not be permitted.

D. At Contractor's Option: In lieu of mechanical spreader, seed may be spread by the hydroseeding method, utilizing power equipment commonly used for that purpose.

1. Seed, lime, fertilizer, and mulch shall be mixed and applied to achieve application quantities specified herein for the conventional seeding method, with mulch applied at the rate of 1,200 lb./acre. Other provisions specified above for conventional seeding shall apply also to hydroseeding.
2. Mulch shall be applied in two stages with 5% to 10% of the quantity applied with seed and the balance applied separately.
3. Seed shall not be placed in water until immediately before application.
4. Centrifugal pumps shall not be used to apply seed mix without fiber mulch. Hand broadcast or use gear pump.
5. Gelscape shall be incorporated at the rate of 15 lb. per acre.

E. Rope off entire seeded area to prevent vehicles and pedestrians from entering area.

3.6 SODDING

A. Edges of the sodded areas shall be smooth, and all sodded areas shall conform to the design cross sections and grade. At edges adjacent to curbs, paved areas, etc., top surface of earth in sod shall be 1/2 in. below adjacent hard surface.

B. Sod shall be placed and all sodding operations completed within 72 hours following stripping from sod source bed.

C. On slopes steeper than 2 to 1, sod shall be fastened in place with suitable wood pins or other approved methods, spaced at not less than 1 pin per square foot.

D. Surface of completed sodded area shall be smooth. Sod shall be laid edge-to-edge, with tight-butted, staggered joints. Sod shall be carefully placed to ensure that it is neither stretched or overlapped. Immediately after laying sod shall be pressed firmly into contact with sod bed by tamping or rolling, to eliminate air pockets. Following compaction, topsoil shall be used to fill all cracks, and excess soil shall be worked into grass with rakes or other suitable equipment. Sod shall not be smothered with excess fill soil.

E. Immediately after sodding operations have been completed, entire surface shall be compacted with a cultipacker roller or other approved equipment weighing 100 to 160 lb./ft. of roller.

F. Completed sod shall immediately be watered sufficiently to uniformly wet the soil to at least 1 in. below the bottom of sod bed.

3.7 MAINTENANCE

A. Except as otherwise specified below, maintenance shall include all operations required to produce an established lawn, including but not limited to:
   1. Fertilizing
   2. Mowing
   3. Replanting
   4. Watering
   5. Weeding

B. Maintenance of seeded areas shall begin upon completion of seeding and shall continue through completion of two mowings as specified below is completed.
   1. Watering
      a. Week No. 1: Provide all watering necessary to keep seed bed moist at all times. Perform watering daily or as necessary to maintain moist soil to a depth of 4 in.
      b. Week No. 2 and until acceptance of the building, or until mowing as specified below is completed. Water as necessary to maintain adequate moisture in the upper 4 in. of soil to promote seed germination.
   2. Mowing
      a. Not more than 40% of the grass leaf shall be removed during the first or subsequent mowings.
      b. Bluegrass and other cool season grasses shall be maintained between 1-1/2 in. and 2-1/2 in.
      c. All clippings shall be removed.

C. Maintenance of sodded areas shall begin upon completion of sodding and shall continue a minimum of 45 days thereafter including two mowings, unless sodding is not completed until after September 15, in which case maintenance shall continue through June 15 the following year.
   1. Watering
      a. Week No. 1: Provide all watering necessary for rooting of sod. Soil on sod pads shall be kept moist at all times. Perform watering daily or as necessary to maintain moist soil to a depth of 4 in. Watering shall be done during the heat of the day to prevent wilting.
      b. Week No. 2 and Subsequent Weeks: Water as necessary to maintain adequate moisture in the upper 4 in. of soil to promote deep root growth.
   2. Mowing

a. Mowing shall not be attempted until the sod is firmly rooted and securely in place. Not more than 40% of the grass leaf shall be removed during the first or subsequent mowings.

b. Bluegrass and other cool season grasses shall be maintained between 1-1/2 in. and 2-1/2 in.

c. All clippings shall be removed.

d. After 2 mowings, the Contractor shall top dress the sod with an application of fertilizer at the rate of 1 pound of actual nitrogen per 1000 square feet.

D. After grass has sprouted, seeded areas which fail to show a uniform stand of grass shall be replanted as often as necessary to establish an acceptable stand of grass with no visible bare spots > 4".

E. Weeds and growth other than varieties of grass named in grass seed formula shall be removed. Removal may be accomplished by use of suitable herbicides or by physical removal, in which case top growth and roots shall both be removed, and bare spots exceeding specified limits shall be reseeded. Owner approval required prior to any application of fertilizer or herbicide.

F. If lawn or grass is established in the fall and maintenance is required to continue into spring months, lawn and grass shall receive an application of lime and fertilizer in the spring. Lime and fertilizer shall be spread in a uniform layer over the entire lawn surface, at the following rates.

Material	Application Rate
Lime	100 lb./1000 sq. ft.
Fertilizer	20 lb./1000 sq. ft.

G. Remove rope barricades only after second cutting of lawns.

3.8 FILTER FABRIC AREAS

A. Filter fabric is to be installed at depth and in locations as shown on the Drawings.

3.9 LANDSCAPE EDGING

A. Landscape edging shall be installed in locations as shown on the Drawings as per Section 329113.16, MULCH.

END OF SECTION

Section 32 93 00

TREES, PLANTS, AND GROUNDCOVERS

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all Sections within DIVISION 01, GENERAL REQUIREMENTS which are hereby made a part of this Section of the Specifications.

1.2 DESCRIPTION OF WORK

A. Provide all materials and equipment, and do all work required to complete the planting, including furnishing and placing planting soil, as indicated on the Drawings and as specified.

1.3 RELATED SECTIONS

A. Examine Contract Documents for requirements that affect work of this Section. Other Specification Sections that directly relate to work of this Section include, but are not limited to:

1. Section 31 20 00, EARTH MOVING.
2. Section 32 80 00, IRRIGATION SYSTEM.
3. Section 32 91 12.16 MULCH.
4. Section 32 92 00, LAWN AND GRASSES.

1.4 REFERENCES

A. Comply with applicable requirements of the following standards. Where these standards conflict with other specified requirements, the most restrictive shall govern:

1. American National Standards Institute, Inc. (ANSI):

   Z60.1 American Standard for Nursery Stock (Sponsor: American Nursery and Landscape Association)

   A 300 American National Standards for Tree Care Operations

2. American Society for Testing and Materials (ASTM):

   C 136 Sieve Analysis of Fine and Coarse Aggregates

   D 422 Particle-Size Analysis of Soils

   E 11 Wire-Cloth Sieves for Testing Purposes

   F 405 Corrugated Polyethylene (Pe) Tubing and Fittings

3. “Hortus Third", A Concise Dictionary of Plants Cultivated in the United States and Canada, Cornell University, L.H. Bailey Hortorium, MacMillian Publishing Co., New York, NY.
4. Florida Grades and Standards for Nursery Plants, Florida Department of Agriculture and Consumer Services, Adam H. Putnam, Commissioner. For plant material ratings per ANSI 60 standards.

1.5 SUBMITTALS

A. Samples: The following samples shall be submitted:

Material	Sample Size or Quantity
Planting soil	1 lb. each mix type
Organic Compost	1 lb.
Imported Base Loam	1 lb.
Coarse Sand	1 lb.

B. Sources for Soil Components and Soil Mixes: Submit information identifying sources for all soil components and the firm responsible for mixing of soil mixes.
1. Landscape Architect shall have the right to reject any soil source provider. Soil components and blends must be approved in writing prior to delivery to site.

C. Certificates: Labels and reports from the manufacturer/supplier certifying that the product meets the specified requirements shall be submitted for the following materials:
1. Commercial fertilizer
2. Limestone
3. Compost
4. Coarse Sand
5. Imported Loam
6. Stockpiled Site Loam (Contractor to have tested and submit report to Landscape Architect if intending to use as base loam, do NOT screen loam prior to submitting samples)

D. Manufacturer's Product Data: Manufacturer's product data shall be submitted for the following materials:
1. Antidessicant
2. Fungicide
3. Herbicide
4. Insecticide
5. Tree wrap

E. Test Reports: Test reports from an approved testing agency indicating compliance with the specifications shall be submitted for topsoil and any other materials designated by the Architect.

F. Planting Schedule: Indicating anticipated planting dates for each type of planting a minimum of 2 weeks prior to installation to Landscape Architect for scheduling.

G. Proposed maintenance program for plants during one-year guarantee period and for temporary irrigation system for minimum 24 month establishment period.

1.6 OWNER'S INSPECTION AND TESTING

A. Work will be subject to inspection at all times by the Architect. The Owner reserves the right to engage an independent testing laboratory to analyze and test materials used in the construction of the work. Where directed by the Architect, the testing laboratory will make material analyses and will report to the Architect whether materials conform to the requirements of this specification.

1. Cost of tests and material analyses made by the testing laboratory will be borne by the Contractor.
2. Testing equipment will be provided by and tests performed by the testing laboratory.

1.7 CONTRACTOR'S INSPECTION AND TESTING

A. The Contractor shall engage an independent testing agency, experienced in the testing of agricultural/manufactured soils and acceptable to the Architect, to perform the topsoil/planting soil tests and analyses specified herein. All costs associated with testing shall be the Contractor's responsibility.

1. Particle size analysis shall include the following gradient of mineral content:

USDA Designation	Size in mm
Gravel	+ 2 mm
Very coarse sand	1-2 mm
Coarse sand	0.5-1 mm
Medium sand	0.25-0.5 mm
Fine sand	0.1-0.25 mm
Very fine sand	0.05-0.1 mm
Silt	0.002-0.05 mm
Clay	< 0.002 mm

2. Chemical analysis shall include the following:
   a. pH and buffer pH
   b. percentage of organic content by oven-dried weight
   c. Nutrient levels by parts per million, including phosphorus, potassium, magnesium, manganese, iron, zinc, and calcium. Nutrient test shall include testing laboratory recommendations for supplemental additions to the soil, if necessary, based on the requirements for ornamental horticultural plants. Recommendations shall include rates at which additives are to be applied.
   d. Soluble salt by electrical conductivity of a 1:2 soil/water sample.
   e. Cation Exchange Capacity

1.8 SOURCE QUALITY CONTROL

A. Identification of plant materials shall be as named in "Hortus Third".

B. Selection of Plant Materials: Contractor shall submit to Architect a complete list of all proposed nurseries including location, contact #, plant list for each nursery, all proposed substitutions, credits and/or additional charges. No tagging will occur until this list is complete and submitted. Contractor shall be responsible for delays if list is not submitted complete and in advance of proposed tagging dates.
   1. Inspect all nursery materials to determine that the materials meet the requirements of this section. Proposed materials shall be flagged by the nurseries for review by the Contractor and the Architect.
   2. Schedule with the Architect a time for viewing plant material at the nursery. Trips to nurseries shall be efficiently arranged to allow Architect to maximize viewing

time. A minimum of six weeks shall be allowed for this viewing prior to time that plants are to be dug.

3. Architect may choose to attach seal to each plant, or representative samples.
4. Viewing and/or sealing of plant materials by the Architect at the nursery does not preclude the Architect's right to reject material at the site of planting.
5. Architect will provide a maximum of two (2) tagging trips within 2.5 hour drive from Boston, MA.

C. Plant Photographs: For any plants not tagged by Landscape Architect, contractor is to provide color photographs in digital format of each required species and size of plant material as it will be furnished for the Project. Take photographs from an angle depicting true size and condition of the plant to be provided. Include a scale rod or other measuring device in each photograph. Include a minimum of three photographs showing best plant quality and worst plant quality for each species to be furnished. Clearly identify photographs with botanical name, size and source nursery.

1.9 QUALITY ASSURANCE

A. Installer Qualifications:A qualified landscape Installer whose work has resulted in successful establishment of plants. Installer shall provide evidence of the following credentials:

1. Professional Membership: Installer shall be a member in good standing of either the Professional Landcare Network or the American Nursery and Landscape Association.
2. Experience: Five years' experience in landscape installation in addition to requirements in Division 01 General Requirements."
3. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when work is in progress.
4. 3 projects similar scale (within 10% of SF of proposed project) within last 5 years
5. 3 references with phone numbers
6. 3 photos each for each reference project
7. Positive responses from all references
8. Reference project review by Architect and Owner within New England area
9. Proof of no current or past litigation over project work.

B. Pesticide Applicator: State licensed, commercial.

C. Soil-Testing Laboratory Qualifications: An independent or university laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed. The following are acceptable testing agencies for the various components:

1. Leaf Yard Waste Compost Stability Test and Pathogens/ Metals/ Vector Attraction: Woods End Research Laboratory, P.O. Box 297, Mt. Vernon, ME, 04352, tel: 201.293.2457, fax: 201.293.2488.
2. Leaf Yard Waste Compost/ All other tests except those listed above: University of Massachusetts, West Experiment Station, Amherst, MA 01003, tel: 413.545.2311, fax: 413.545.1931.
3. Mechanical Gradation and Chemical Analysis, All Components and Soil Mixes: University of Massachusetts, West Experiment Station, Amherst, MA 01003, tel: 413.545.2311, fax: 413.545.1931. or Approved Equal.

D. Certificate/Certified Reports: Within 2 weeks of placement, contractor shall submit certification that all soil blend components and all soil blends meet all environmental standards of the Commonwealth of Massachusetts and the specifications herein.

E. Submit certified reports for the following data for all proposed blended planting soils:
1. Mechanical gradation (sieve analysis) shall be performed and compared to the USDA Soil Classification System. Percent clay (0.002 mm) shall be reported separately in addition to silt (ASTM D-422-63, hydrometer method).
2. The silt and clay content shall be determined by a Hydrometer Test of soil passing the #270 sieve.
3. Chemical analysis shall be undertaken for Phosphorus, Potassium, Calcium Magnesium, Aluminum, Iron, Manganese, Lead, Cation Exchange Capacity, Soluble Salts, acidity (pH) and buffer pH. Recommendations for pH adjustments and fertilizer soil amendments shall be included with all test reports.
4. Certified reports on analyses from producers of composted organic materials are required, particularly when sources are changed. Analyses will include all tests for criteria specified in 2.2C.
5. Density Tests: In-place density testing is required in all areas. Placed planting soils must be inspected for compaction level by the soil scientist or by the following: ASTM D1556 Density of Soil and Rock In Place Using Sand Cone Method, ASTM D6938-10 Nuclear Methods or ASTM D2167-08 Rubber Balloon method after conducting ASTM D698 Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort. In-place density tests shall be carried out at a rate of one test per 1,000 square feet for each type of material placed.
6. Allow sufficient time to obtain all blended soil test approval and obtain the maximum dry density and optimum moisture content by ASTM 698 Standard Proctor Test.

F. In-place percolation tests shall be performed using Turf-Tec IN2-W Infitrometer utilizing manufacturer's operating instructions. Turf-Tech IN2-W Infiltrometer as manufactured by Turf Tec International, 1471 Capital Circle NW, Suite #13, Tallahassee, FL 32303. Order Line 800-258-7477, Phone 850-580-4026, Fax 850-580-4027.
1. In-place infiltration tests shall be carried out at a rate of one test per each 1,000 square feet in lawn areas and planting beds.

1.10 PLANT MATERIAL QUANTITIES

A. In the event of a discrepancy in plant material quantities between the Drawings and the Plant List(s), the larger quantity shall be required.

1.11 UNAVAILABILITY OF PLANT MATERIALS

A. Before changes or substitutions can be made due to unavailability of plant material, submit satisfactory evidence that the Contractor has advertised for a one month period in a trade journal such as the "American Nurseryman", (Tel. 312-427-7339 and Fax: 312-427-7346), with no response, or has undertaken other methods of locating plant material acceptable to the Architect. No planting substitutions are allowed without written approval of Landscape Architect.

1.12 DELIVERY, STORAGE, AND HANDLING

A. Transportation of Plant Material: Plants transported to the project in open vehicles shall be covered with tarpaulins or other suitable covers securely fastened to the body of the vehicle to prevent injury to the plants. Closed vehicles shall be adequately ventilated to prevent overheating of the plants. Trees shall not be transported when daytime air temperatures are below 20°.
   1. Plants shall be kept moist, fresh, and protected at all times. Such protection shall encompass the entire period during which the plants are in transit, being handled, or are in temporary storage.
   2. Unless otherwise authorized by the Architect, notify the Architect at least five working days in advance of the anticipated delivery date of any plant material. A legible copy of the bill of lading, showing the quantities, kinds, and sizes of materials included for each shipment shall be furnished to the Architect, if requested.

B. Storage: Unless specific authorization is obtained from the Architect, unprotected plants shall not remain on the site of work longer than three days prior to being planted.
   1. Plants that are not planted immediately shall be protected as follows:
      a. Earth balls shall be kept moist, not be allowed to freeze, and their solidity carefully preserved.
   2. Both the duration and method of storage of plant materials shall be subject to the approval of the Architect.

C. Handling of Plant Materials: Exercise care in handling plant materials to avoid damage or stress.

1.13 REJECTION OF MATERIALS

A. Evidence of inadequate protection following digging, carelessness while in transit, or improper handling or storage, shall be cause for rejection.

B. Upon arrival at the temporary storage location or the site of the work, plants shall be inspected for proper shipping procedures. Plants with roots dried out, large branches broken, balls of earth broken or loosened, or areas of bark torn shall be subject to rejection by the Architect.

C. Rejected plants shall be removed from the area of work and replaced with same species of the required size and quality.

D. Architect may reject plants on site if they do not meet quality requirements and/or form represented in photo submittals.

1.14 DIGGING/PLANTING SEASONS

A. Spring Digging: Spring digging of plant materials may commence as soon as the ground has thawed and weather conditions make it practicable to dig at the nursery.
   1. Deciduous plants shall not be dug after they have leafed out.
   2. Broadleaf evergreens and conifers shall not be dug after new growth or candle push is visible.

B. Fall Digging: Fall digging of plant materials may commence after dormancy has begun and shall continue until such time as the ground has frozen or weather conditions make it impractical to work.
   1. Fall digging hazards shall conform to American National Standards Institute, Inc. (ANSI) species and guidelines.

C. Planting Seasons: Planting shall only be performed when weather and soil conditions are suitable for planting the material specified, in accordance with locally accepted practice, approval of the Architect, and to maintain the Contractor's guarantee.

1.15 ACCEPTANCE FOR SUBSTANTIAL COMPLETION

A. The Architect shall inspect all work of this Section for Acceptance for Substantial Completion upon receipt of written notice of completion by the Contractor. The request shall be received at least ten calendar days before the anticipated date of inspection.

B. Acceptance of plant material by the Architect shall be for general conformance to specified size, character, and quality, and shall not diminish responsibility for full conformance to the Contract Documents.

C. Upon completion and reinspection of all repairs or renewals necessary in the judgement of the Architect, the Architect shall recommend that Acceptance for Substantial Completion of the work of this Section be given by the Owner.

D. Acceptance in Part
   1. The work may be Accepted in parts when it is deemed to be in the Owner's best interest to do so, and when permission is given to the Contractor in writing to complete the work in parts.
   2. Acceptance and use of such areas by the Owner shall not waive any other provisions of this Contract.

1.16 MAINTENANCE

A. The Contractor shall maintain plant material until the completion of the guarantee period and Final Acceptance of work, as described in paragraph 3.19 of this Section.

1.17 GUARANTEE:

A. Plants shall be guaranteed for a period of one year after the date of Acceptance by the Owner.
   1. When the work is Accepted in parts, the guarantee periods shall extend from each of the partial Acceptances to the terminal date of the last guarantee period. Thus, all guarantee periods terminate at one time.

B. Plants shall be healthy, free of pests and disease, and in flourishing condition at the end of the guarantee period. Plants shall be free of dead and dying branches and branch tips, and shall bear foliage of normal density, size, and color.

1.18 Replace any plant material with 50% or more dead material. Any plant that exhibits less than 50% dead material that no longer consistent with original ANSI standards for form, crown symmetry, etc. may be requested to be replaced at the direction of the landscape architect and Owner. All plants not in a vigorous, thriving condition, as

determined by the Architect during and at the end of the guarantee period, without cost to the Owner, as soon as weather conditions permit and within the specified planting period.

1. Replacements shall closely match adjacent specimens of the same species. Replacements shall be subject to all requirements stated in this Specification.
2. Make all necessary repairs due to plant replacements. Such repairs shall be done at no extra cost to the Owner.
3. The guarantee of all replacement plants shall extend for an additional one year period from the date of their Acceptance after replacement. In the event that a replacement plant is not acceptable during or at the end of the said extended guarantee period, the Owner may elect one more replacement or credit for each item.

B. At the end of the guarantee period, and no less than five days prior to final inspection, staking and guying materials, and ties shall be removed from the site.

1.19 FINAL INSPECTION AND FINAL ACCEPTANCE

A. At the end of the guarantee period, the Architect shall, upon receipt of written notice of end of guarantee period, inspect the work for Final Acceptance. Request shall be received at least ten calendar days before the anticipated date for Final Inspection.

B. Upon completion and reinspection of full repairs or replacements necessary in the judgment of the Architect at that time, the Architect shall recommend to the Owner that Final Acceptance of the work of this Section be given.

PART 2 - PRODUCTS

2.1 PLANTS

A. Except as otherwise specified, size and grade of plant materials and their root balls shall conform to ANSI Z60.1.

B. Plants shall have outstanding form; symmetrical, heavily branched with an even branch distribution, densely foliated and/or budded, and a strong, straight, distinct leader where this is characteristic of species. Plants shall possess a normal balance for the species between height and spread. The Architect will be the final arbiter of acceptability of plant form.

1. Shade Trees: Single-stem trees with straight trunk, well-balanced crown, and intact leader, of height and caliper indicated, complying with ANSI Z60.1 for type of trees required.
2. Small Trees: Branched or pruned naturally according to species and type, with relationship of caliper, height, and branching according to ANSI Z60.1.
3. Multistem Trees: Branched or pruned naturally according to species and type, with relationship of caliper, height, and branching according to ANSI Z60.1.
4. Deciduous Shrubs: Form and Size: Deciduous shrubs with not less than the minimum number of canes required by and measured according to ANSI Z60.1 for type, shape, and height of shrub.
5. Coniferous Evergreens: Form and Size: Normal-quality, well-balanced, coniferous evergreens, of type, height, spread, and shape required, complying with ANSI Z60.1.

6. Coniferous Evergreens: Form and Size: Specimen-quality, exceptionally heavy, tightly knit, symmetrically shaped coniferous evergreens.
7. Broadleaf Evergreens: Form and Size: Normal-quality, well-balanced, broadleaf evergreens, of type, height, spread, and shape required, complying with ANSI Z60.1.

C. Plants shall be healthy and vigorous, free of disease, insect pests and their eggs, and larvae.

D. Plants shall have a well-developed fibrous root system.

E. Plants shall be free of physical damage such as scrapes, broken or split branches, scars, bark abrasions, sunscalds, fresh limb cuts, disfiguring knots, girdling roots, spilt leaders or other defects.

F. All weeds present in root balls or containers shall be physically removed by the contractor prior to planting.

G. Plants shall meet the sizes indicated on the Plant List. Plants larger or smaller than specified may be used only if accepted in writing by the Architect.

H. Where a size or caliper range is stated, at least 50% of the material shall be closer in size to the top of the range stated.

I. Plants shall not be pruned before delivery.

J. All trees and shrubs shall be labeled. Labels shall be durable and legible, stating the correct plant name and size in weather-resistant ink or embossed process. Labels shall be securely attached to all plants prior to delivery to the site, being careful not to restrict growth.

K. Plants indicated as "B&B" shall be balled and burlapped.
1. Unless otherwise permitted by the Architect, plants shall be nursery grown.
2. Plants shall be grown for at least two years under climatic conditions similar to those in the locality of the Project.
3. Nursery grown plants shall be dug in the current planting season. No heeled in plants or plants from cold storage that were dug in the previous season shall be accepted.
4. No trees shall be container grown.

L. Container grown shrubs and perennials shall be well rooted and established in the container in which they were grown. They shall have grown in the container for a sufficient length of time for the root system to hold the planting medium when taken from the container, but not long enough to become root bound. Container grown plants exceeding the sizes indicated in ANSI Z60.1 shall have containers which are not less than 75% of the ball sizes for comparable B&B plant material. Each container plant shall be inspected and circling roots loosened or pruned as needed. Any root bound woody plant will not be accepted.

M. Canes or Trunk(s) and Branches:

1. Very well formed and sturdy with distinct leader and no crotches that may interfere with growth of leader. Trees with included bark in crotches shall be avoided.
2. Branching well spaced and uniformly distributed both vertically and around the circumference to form a well balanced plant.
3. Scars shall be free of rot and not exceed ¼ the diameter of the wood beneath in greatest dimension unless completely healed (except pruning scars).
4. Pruning scars clean cut leaving little or no protrusion from the trunk or branch.
5. Graft union completely healed.
6. No mechanical or pest damage.
7. No extreme succulence.
8. Evidence of adequate twig growth in the past 2-4 years, and well-formed buds.
9. Rootflare must be exposed to adequate depth and be visible.

N. Foliage:

1. Densely supplied with healthy, vigorous leaves of normal size, shape, color and texture (except shrubs moved bare-root or deciduous shrubs when dormant).
2. One half of the foliage should be growing on the lower 2/3 of the trunk.
3. No chlorosis.
4. No more than 5% of total foliage affected by pest or mechanical damage.

O. Root System:

1. Sturdily established and evenly distributed.
2. Container grown plants shall be well developed and hold the soil ball together when removed from the container.
3. Container grown plants shall not be rootbound with any circling or girdling roots.

2.2 PLANTING SOIL

A. Base Loam

1. Existing topsoil from on-site source(s) may be used for planting loam, to the extent available, if it meets the requirements of this Section for planting soil, or if approved by the Architect.
2. If the existing topsoil does not meet requirements imported base loam should be sourced and tested to meet requirements of the project.
    a. Imported Base Loam or existing top soil used as a base loam, as required for blending with sand and compost, shall be a naturally occurring soil formed from geologic soil forming processes without admixtures of sand or organic matter sources (composts). Base Loam, which has been contaminated by incorporation of subsoil, shall not be acceptable for use. Base Loam shall be free of quack-grass rhizomes, Agropyron Repens, and the nut-like tubers of nutgrass, Cyperus Esculentus, and all other primary noxious weeds. Base Loam shall not be delivered or manufactured into soil blends while in a frozen or muddy

condition. Base Loam for mixing shall conform to the following grain size distribution for material passing the #10 sieve:

	Percent Passing	
U.S. Sieve Size Number	Minimum	Maximum
10	---	100
18	85	100
35	70	95
60	50	85
140	36	53
270	32	42
0.002mm	3	6

b. The ratio of the particle size for 80% passing (D80) to the particle size for 30% passing (D30) shall be 8 or less (D80/D30 < 8).

c. Maximum size shall be one-inch largest dimension. The maximum retained on the #10 sieve shall be 20% by weight of the total sample. Tests shall be by combined hydrometer and wet sieving in compliance with ASTM D422 after destruction of organic matter by ignition.

d. The organic content shall be between 4.0 and 8.0 percent by weight.

e. pH shall be between 5.8 and 7.0.

f. Chemical analysis shall be undertaken for Phosphorus, Potassium, Calcium Magnesium, Aluminum, Iron, Manganese, Lead, Soluble Salts, acidity (pH) and buffer pH.

g. Cation Exchange Capacity shall be between 13-30.

B. Coarse Sand

1. Sand for Planting Soil Blends, protection of filter fabric and for drainage as required, shall be uniformly graded medium to coarse sand consisting of clean, inert, rounded to sub-angular grains of quartz or other durable rock free from loam or clay, mica, surface coatings and deleterious materials with the following grain size distribution for material passing the #10 sieve:

	Percent Passing	
U.S. Sieve Size Number	Minimum	Maximum
10	100	---
18	60	80
35	25	45
60	8	20
140	0	8
270	0	3
.002mm	0	.05

2. The maximum retained on the #10 sieve shall be 20% by weight of the total sample.

3. The ratio of the particle size for 70% passing (D70) to the particle size for 20% passing (D20) shall be 3.0 or less (D70/D20 <3.0). Tests shall be by combined hydrometer and wet sieving in compliance with ASTM D422.

4. pH shall be less than 7.5.

C. Organic Amendment (Compost)

1. Organic Matter for amending planting soils shall be a stable, humus-like material produced from the aerobic decomposition and curing of Leaf Yard Waste Compost, composted for a minimum of one year (12 months). The leaf yard waste compost shall be free of debris such as plastics, metal, concrete or other debris. The leaf yard waste compost shall be free of stones larger than 1/2", larger branches and roots. Wood chips over 1" in length or diameter shall be removed by screening. The compost shall be a dark brown to black color and be capable of supporting plant growth with appropriate management practices in conjunction with addition of fertilizer and other amendments as applicable, with no visible free water or dust, with no unpleasant odor, and meeting the following criteria as reported by laboratory tests.
    a. The ratio of carbon to nitrogen shall be in the range of 12:1 to 25:1.
    b. Stability shall be assessed by the Solvita procedure. Protocols are specified by the Solvita manual (version 4.0). The compost must achieve a maturity index of 6 or more as measured by the Solvita scale. Stability tests shall be conducted by Woods End Research Laboratory, Mt. Vernon, Maine.
    c. Pathogens/Metals/Vector Attraction reduction shall meet 40 CFR Part 503 rule, Table 3, page 9392, Vol. 58 No. 32, and Commonwealth of Massachusetts 310 CMR 32.00 (for applications to soils with human activity).
    d. Organic Content shall be at least 20 percent (dry weight). One hundred percent of the material shall pass a 1/2-inch (or smaller) screen. Debris such as metal, glass, plastic, wood (other than residual chips), asphalt or masonry shall not be visible and shall not exceed one percent dry weight. Organic content shall be determined by weight loss on ignition for particles passing a number 10 sieve according to procedures performed by the West Experiment Station at the University of Massachusetts, Amherst or equal.
    e. pH: The pH shall be between 6.5 to 7.4 as determined from a 1:1 soil-distilled water suspension using a glass electrode pH meter American Society of Agronomy Methods of Soil Analysis, Part 2, 1986.
    f. Salinity: Electrical conductivity of a one to five soil to water ratio extract shall not exceed 2.5 mmhos/cm (dS/m).
    g. The compost shall be screened to 1/2-inch maximum particle size and shall contain not more that 3 percent material finer that 0.002mm as determined by hydrometer test on ashed material.
    h. Nutrient content shall be determined by the University of Massachusetts Soil Testing Laboratory or equivalent laboratory and utilized to evaluate soil- required amendments for the mixed soils. Chemical analysis shall be undertaken for Nitrate Nitrogen, Ammonium Nitrogen, Phosphorus, Potassium, Calcium, Aluminum, Magnesium, Iron, Manganese, Lead, Soluble Salts, Cation Exchange Capacity, soil reaction (pH), and buffer pH.

2.3 PLANTING SOIL MIXES

A. All existing vegetation shall be removed from stockpiles prior to blending. Uniformly mix ingredients by windrowing/tilling on an approved hard surface area. All soil components and Organic Amendment shall be maintained moist, not wet, during

mixing. Amendments shall not be added unless approved to extent and quantity by the owner and additional tests have been conducted to verify type and quantity of amendment is acceptable. Percentages of components are approximate, and will be verified upon completion of individual test results for components of the various mixes. Due to variability of soil materials, mix ratios may require adjustment and re-submittal at the expense of the Contractor.

B. After component percentages are determined by the Landscape Architect, each planting soil mix shall be tested for physical and chemical analysis. Component percentages may be modified at any time by the Landscape Architect dependent upon the results of testing of the various components or final blends.

C. Perennial, Shrub and Tree Pit Soils

1. This planting Bed Soil shall consist of a combination of approximately by volume one and a half parts Stripped Existing or Imported Base Loam, two parts Coarse Sand and one part Organic Amendment/Compost (1.5L:2S:1C). The following gradation for material passing a Number 10 Sieve shall be achieved in the final mix.

	Percent Passing	
U.S. Sieve Size No.	Minimum	Maximum
10	100	---
18	85	95
35	60	85
60	42	65
140	21	44
270	18	24
0.002 mm	2	4

2. Maximum size shall be one half-inch largest dimension. The maximum retained on the #10 sieve shall be 10% by weight of the total sample.
3. The ratio of the particle size for 80% passing (D80) to the particle size for 30% passing (D30) shall be 6 or less (D80/D30 <6).
4. The final mix shall have an organic content between 5 and 7 percent by weight.
5. The final mix shall have a hydraulic conductivity of not less that 1.5 inches per hour according to test procedure ASTM D5856-95 (2000) hour when compacted to a minimum of 86 percent Standard Proctor ASTM D 698. Tests shall be by combined hydrometer and wet sieving in compliance with ASTM D422 after destruction of organic matter by ignition.
6. Final mix shall have a pH between 6.0-7.3
7. Final mix shall have a Cation Exchange Capacity between 13-30.
8. Chemical analysis shall be undertaken for Phosphorus, Potassium, Calcium Magnesium, Aluminum, Iron, Manganese, Lead, Soluble Salts, acidity (pH) and buffer pH.

D. Sand Based Structural Soil

1. Existing topsoil shall not be used to blend Sand Based Structural Soil. Imported Base Loam, Sand and Compost, each as specified above, shall be combined in an approximate mix ratio of four parts by volume Sand to one part by volume

Imported Base Loam to one and one half part by volume Compost (4S:1L:1.5C) to create a uniform blend which meets the following requirements.

2. Gradation for Material Passing the Number 10 Sieve: percent Passing by Weight

U.S. Sieve Size Number	Minimum	Maximum
10	100	-
18	68	90
35	38	63
60	18	39
140	9	18
270	8	10
0.002mm	1	2

3. Maximum size shall be one-inch largest dimension. The maximum retained on the #10 sieve shall be 15percent by weight of the total sample.
4. Ratio of the particle size for 70 percent passing (D70) to the particle size for 20 percent passing (D20) shall be 3.2 or less. (D70/D20 <3.2)
5. Saturated hydraulic conductivity of the mix: not less than 6 inches per hour, According to ASTM D5856-95 (2000) when compacted to a minimum of 92 percent Standard Proctor, ASTM 698.
6. Organic content: between 2.5 and 3.5 percent by weight.
7. The pH shall be between 6.0 and 6.8.
8. After approval of the above horticultural testing, conduct Standard Proctor Test (ASTM 698) to obtain maximum dry density and optimum moisture content values.
9. Chemical analysis shall be undertaken for Phosphorus, Potassium, Calcium Magnesium, Aluminum, Iron, Manganese, Lead, Cation Exchange Capacity, Soluble Salts, acidity (pH) and buffer pH.

E. Horticultural Subsoil (Tree Pit Subsoil)

1. Horticultural Subsoil for the lower layer of planting soil in Planting Beds shall consist of a combination of approximately 2 parts by volume Coarse Sand to one part by volume Stripped Existing Topsoil or Imported Base Loam (2S:1L).
2. Gradation for material passing the #10 sieve:

	Percent Passing	
U.S. Sieve Size No.	Minimum	Maximum
10	100	--
18	85	95
35	55	80
60	30	60
140	20	33
270	12	17
0.002mm	1	3

3. Maximum size shall be one-inch largest dimension. The maximum retained on The #10 sieve shall be 20percent by weight of the total sample.
4. Ratio of the particle size for 80percent passing (D_{80}) to the particle size for 30percent passing (D_{30}) shall be 6.5 or less (D_{80}/D_{30} <6.5).
5. Saturated hydraulic conductivity of the mix: not less than 2 inches per hour according to ASTM D5856-95 (2000) when compacted to a minimum of 86percent
   Standard Proctor, ASTM 698.
6. Organic content: between 1.5 and 3.0 percent by weight.
7. pH shall be between 6.0 and 6.8.
8. Chemical analysis shall be undertaken for Phosphorus, Potassium, Calcium Magnesium, Aluminum, Iron, Manganese, Lead, Cation Exchange Capacity, Soluble Salts, acidity (pH) and buffer pH.
9. When used on structure, the saturated unit weight of the soil blend (ASTM Method E 2399 – 05) shall not exceed 125 lbs. per cubic foot when compacted to 87percent Standard Proctor Density. Add perlite to the soil blend to reduce saturated weight as required to meet Specification Requirements.

F. Horticultural Subsoil (Tree Pit Subsoil Alternate)

1. Sand Based Structural Soil may be used as the planting medium below 12" of planting soil for use as an alternate to horticultural subsoil within the soil profiles. Sand Based Structural Soil used as horticultural subsoil shall not be vibratory compacted, but shall be compressed as required in Section 3, Execution.
2. The maximum uniformity coefficient (D70/D20) for SBSS used as Horticultural Subsoil may be increased to 4.0

G. Bioretention Soil (see Section 32 94 00 BIORETENTION and civil engineering section for detail)

2.4 LIMESTONE

A. Limestone shall be an approved agricultural limestone containing no less than 50% of total carbonates, and 25% total magnesium with a neutralizing value of at least 100%. The material shall be ground to such a fineness that 40% will pass through a No. 100 U.S. Standard Sieve, and 98% will pass through a No. 20 U.S. Standard Sieve. The lime shall be uniform in composition, dry and free flowing, and shall be delivered to the site in the original unopened containers, each bearing the manufacturer's guaranteed analysis. Any lime which becomes caked or otherwise damaged making it unsuitable for use, will be rejected.

2.5 ALUMINUM SULFATE

A. Aluminum sulfate shall be unadulterated and shall be delivered in containers with the name of the material and manufacturer and net weight of contents.

2.6 WATER

A. Water shall be suitable for irrigation and shall be free from ingredients harmful to plant life.

2.7 FERTILIZER

A. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:

1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing agency. Manufacturer's literature shall be submitted for approval.

B. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water- insoluble nitrogen, phosphorus, and potassium in the following composition:

1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing agency.

2.8 SUPERPHOSPHATE

A. Superphosphate shall be composed of finely ground phosphate rock as commonly used for agricultural purposes, and containing not less than 20% available phosphoric acid. The superphosphate shall be delivered to the site in the original unopened containers, each bearing the manufacturer's guaranteed analysis. Any superphosphate which becomes caked or otherwise damaged making it unsuitable for use, will be rejected.

2.9 MULCH

B. See Section 329113.16 for Mulch

2.10 GUYING AND STAKING MATERIALS IF REQUIRED BY OWNER'S MAINTENANCE PRACTICE.

C. Wood Stakes: Straight, sound, rough sawn lumber 2 in. x 2 in., if square, or 2-1/2 in. diameter, if round. Stakes shall be stained dark green. Wire for staking shall be 12 gauge steel.

D. Wire for Guying: Galvanized steel 1 x 19 preformed 3/16 in. diameter. Thimbles and nicopress clips shall be used for connections and splices.

E. Turnbuckles: ¼" x 73/4" Galvanized steel with a 21/2" in. lengthwise opening fitted with eyebolts, as manufactured by Crown Bolt Inc., or approved equal.

F. Hose: High quality braided rubber hose, 3/4 in. diameter and suitable length, black in color.

G. Strapping: Arbortie, manufactured by DeepRoot Green Infrastructure, LLC, 530 Washington Street, San Francisco, CA 94111Tel: 800 458 7668 or 415 781 9700; Fax: 800; 277 7668 or 415 781 0191, or approved equal.

2.11 ANTIDESICCANT

A. Antidessicant shall be an emulsion specifically manufactured for plant protection which provides a protective film over plant surfaces which is permeable enough to permit transpiration. Antidessicant shall be delivered in manufacturer's sealed containers and shall contain manufacturer's printed instructions for use.

B. Antidessicant shall be equal to the following:

Product	Manufacturer
Wilt-Pruf	Wilt-Pruf Products, Inc., P.O. Box 469 Essex, CT 06426

2.12 FUNGICIDE

A. Fungicide shall be “Hi-Yield” fungicide intended for vegetables, fruits, flowers, and ornamental plantings, or approved equal.

2.13 INSECTICIDE

A. Insecticide shall be “All Seasons” Horticultural Oil, for control of insects and mites, manufactured by BONIDE Products, 6301 Sutliff Rd. Oriskany, NY 13424, or approved equal.

B. Insecticides shall be used sparingly and all must be pollinator-friendly. Submit SDS and chemical analysis for review.

2.14 POST-EMERGENT HERBICIDE

A. Herbicide shall be QuikPRO™ herbicide, formulated as a water-soluble granule and packaged in easy-measure bottles, complete weed control, manufactured by Monsanto, or approved equal.

2.15 PRE-EMERGENT HERBICIDE

A. See Section 32 91 13.16 MULCH for Pre-Emergent Herbicide

PART 3 - EXECUTION

3.1 PREPARATION OF PLANT MATERIALS

A. Immediately before digging and following consultation with the Architect, spray all evergreen or deciduous trees in full leaf with Transplant Biostimulant, applying an adequate film over trunks, branches, twigs and foliage and apply Transplant Biostimulant to the root ball area

B. Dig, and ball and burlap (B&B) plants with firm, natural balls of earth, of depth and diameter not less than that recommended by the American Standard for Nursery stock. Plants moved with a ball will not be accepted if the ball is cracked or broken before or during planting operation. Remove all grass, weeds and accumulated soil resulting from nursery cultivation from the top of the root ball prior to digging so that the original trunk flare shows on top of the root ball.

C. Use only natural burlap and jute twine. Do not use synthetic fibers or wire to ball and burlap root balls. Wire baskets will be acceptable if removed in accordance with these specifications.

D. All plant material in transit or temporary stored shall be covered with burlap or similar covering to keep plants from drying out.

E. Ship and store bare root material in refrigerated trucks and storage areas. Keep roots moist and cool until time of planting.

F. If the construction schedule requires trees over 3 ½" in caliper to be planted in the fall, that are of a species considered to be difficult to transplant in the fall, these trees shall be root pruned the previous spring in the nursery.

1. The Architect will determine tree species to be root pruned.
2. A trench shall be dug around the tree at the limit of the proposed root ball to a minimum depth of 24" and back-filled.
3. A 3" high saucer shall be built around the tree outside the edge of the trench.
4. The tree shall be guyed or braced.
5. The tree shall be watered as necessary through the summer.
6. When the tree is dug in the fall, the digging shall be done using methods that preserve the new root growth growing in the soft soil of the trench.
7. Root pruning, when required, shall be done at no additional cost to the Owner, except for owner pre-purchased trees.

3.2 EXAMINATION OF SUBGRADE

A. Examine subgrade and rough grading before planting. Alert Architect to unacceptable rough grading or subgrade conditions.

3.3 DECOMPACTION OF PLANTING AREAS

A. After subgrade levels have been reached and immediately prior to placing planting soils, the entrie subgrade area shall be loosened to a minimum depth of 12 inches utilizing the bucket of a backhoe or equivalent equipment.

B. Any subgrade areas which have become heavily compacted (defined as exceeding 86% -88% compaction ASTM C698 Standard Proctor) including, but not limited to temporary parking areas, material stockpile areas, temporary roadways, construction areas, areas shown on the plans, or areas identified by Architect shall be deep-scarified. Immediately prior to placing soils, heavily compacted areas shall be loosened to a minimum depth of 36 inches using the teeth of a backhoe or other suitable equipment. Frequency of compaction tests shall be one per 200 square feet.

C. Using a wide-track bulldozer size D-5 or smaller, compact the scarified subgrade to 86% - 88% compaction ASTM D698 Standard Proctor. Contractor shall provide shovel dug test pits to the full depth of the mitigation, where located per the direction of the Architect, in order for the Architect to review whether the work has been done as required. Backfill the pits after the review(s).

D. Confirm that the subgrade is at the proper elevation and that no further earthwork is required to bring the subgrade to proper elevations. Provide a written report to Architect indicating that subgrade has been placed to the required elevations, has been decompacted according to the Contract Documents and is ready for inspection at least 3 days prior to placing planting soil. Perform no work of placing and spreading planting mixes until elevations have been confirmed and written report has been accepted by the Architect.

E. After the soils have been loosened and inspected, topsoil may be spread by using a wide track bulldozer size D-5 or smaller or may be dumped and spread with bucket of a backhoe from the edge of the loosened area. No rubber-tired

equipment or heavy equipment except for small bulldozer shall pass over the subsoils (subgrade) after they have been loosened. If Contractor plans to utilize such areas for any use of heavy equipment, this should be carried out prior to beginning the process of loosening soils or filling in that area, or it shall be rescarified to meet this specification requirement.

3.4 SOIL DRAINAGE/DETRIMENTAL SOILS

A. Test drainage of five planting pits in locations as directed by the Architect. Pits shall be filled with water twice in succession. The time at which water is put into the pit for a second filling shall be noted. Architect shall then be notified of the time it takes for pit to drain completely. Planting operations shall not proceed until Architect has reviewed test drainage results.

1. To test drainage, dig a whole about 1 foot deep. Fill with water and allow it to drain completely. Immediately refill the pit and measure the depth of the water with a ruler. 15 minutes later, measure the drop in water in inches, and multiply by 4 to calculate how much water drains in an hour.
2. Less than 1 inch per hour is poor drainage, indicating the site may stay wet for periods during the year. 1 to 6 inches of drainage per hour is desirable. Any subgrades with perc rates less than 1 in. per hour shall be decompacted and/or replaced as required to meet the specifications.

B. The Contractor shall notify the Architect in writing of all soil or drainage conditions that are considered detrimental to growth of plant material. Submit proposal and cost estimate for correction of the conditions for Architect's approval before starting work.

3.5 LAYOUT OF PLANTING AREAS

A. Individual trees shall be located in the field as indicated on the Drawings for Architect’s approval prior to planting. Contractor shall provide one foreman, one loader with operator and two laborers to work with Architect in the field to determine the final location and orientation of each tree prior to planting. It is anticipated that this process may take several days to complete. Contractor shall plan to have this layout crew available to work with Architect at a slow and deliberate pace in order to achieve the desired results.

B. Individual shrubs and perennials to be planted shall be laid out in plant beds by the Contractor in ample time to allow inspection by the Architect.

3.6 PREPARATION OF SUBGRADE

A. Subgrade of planting areas shall be loosened or scarified to a minimum depth of 3 in. prior to spreading planting soil. Subgrade shall be brought to true and uniform grade and shall be cleared of stones greater than 2 in., sticks, and other extraneous material.

3.7 PLANT PIT EXCAVATION

A. Planting pits for trees and shrubs shall be excavated to the depth and dimensions indicated on the Drawings.

B. Excavation shall not begin until locations are approved by the Architect.

3.8 SPREADING OF PLANTING SOIL

A. Planting soil shall be spread in lifts not greater than 6 inches and compacted to a density between 82% and 86% Standard Proctor Maximum Dry Density in accordance with ASTM D698. The surface area of each lift, including the subgrade after it has been compressed by a backhoe, shall be scarified by raking prior to placing the next lift.

B. Soil shall never be spread, placed, graded or driven over by machinery when wet. Only dry soil can be applied to the site.

C. Place and spread planting medium to a depth greater than required such that after settlement, finished grade shall conform to the lines, grades and elevations shown on the Drawings. Ensure proper drainage in an uninterrupted pattern free of hollows and pockets.

D. Remove roots, stumps, litter and other foreign material and stones over 1 inch diameter and legally dispose of off-site.

E. Surfaces shall be graded and smoothed, eliminating all sharp breaks by rounding, scraping off bumps and ridges, and filling in holes and cuts.

3.9 PLANTING

A. Tree, shrub, and groundcover beds shall be excavated to the depth and widths indicated on the Drawings. If the planting pit for any tree is dug too deep, soil shall be added to bring it to correct level, and the soil shall be thoroughly tamped. Walls of plant pits shall be dug so that they are sloped as shown on the Drawings, and scarified. Do not excavate compacted subgrades of adjacent pavement or structures.

B. Plants shall be set as indicated on Drawings. Plants shall be set so that the root flare is at, or slightly above, finished grade. Plants located in poorly drained soils shall be set 2 to 4 inches above finished grade, gradually sloping between the top of the root ball and the surrounding finished grade.

C. Plants shall be turned to the desired orientation when required by Architect. Containerized plants shall be removed from container taking care not to damage roots. The side of the root ball shall be scarified to prevent root-bound condition before positioning in planting pit.

D. Plants shall be positioned in center of planting pits, set plumb, and rigidly braced in position until all planting soil has been tamped solidly around the balls.

E. Pits shall be backfilled with planting soil. Soil shall be worked carefully into voids and pockets, tamping lightly every 6 in.

1. When pit is two-thirds full, plants shall be watered thoroughly, and water left to soak in before proceeding.
2. At this time, ropes or strings on top of balls shall be cut and shall be pulled back. Burlap or cloth wrapping shall be left intact around ball except that portions of wrap that are exposed at top of ball shall be turned under and buried. Non-biodegradable ball wrapping and support wire shall be totally removed from ball and planting pit.

3. Wire baskets shall be completely cut away from sides of root ball, and removed from pit. Bottom of basket may remain.
4. Remove nursery plant identification tags.

F. Backfilling and tamping shall then be finished and a saucer formed around plant pits as indicated on the Drawings.

G. Saucer shall be filled with water and water left to soak in. Saucer shall then be filled with water again.

3.10 PERENNIALS

A. Set out and space plants 12 inches (300 mm) apart.

B. Perennials: Dig at least 18" deep, but 12" is adequate. Work 4-6" humus into the top layers of soil by digging or tilling.

C. Perennials: Check root ball after removing plant from its container. Encircling roots need to be gently loosened from the tight mat of root-bound plants. If roots are very dense at bottom of pot, slice off the bottom 1". If roots are seriously disturbed when planting, cut back some foliage to reduce the water stress that will occur. Plant at the same soil level as the plant was in its container.

D. Work soil around roots to eliminate air pockets and leave a slight saucer indentation around plants to hold water.

E. Water thoroughly after planting, taking care not to cover plant crowns with wet soil.

F. Protect plants from hot sun and wind; remove protection if plants show evidence of recovery from transplanting shock.

3.11 FERTILIZER APPLICATION

A. Fertilizer, if required, shall be applied at the rates recommended by soil testing results.

3.12 FUNGICIDE

A. Immediately after planting, all trunks of deciduous trees shall be sprayed with fungicide, applied as directed by chemical manufacturer.

3.13 PRE-EMERGENT-HERBICIDE

A. Immediately after planting, pre-emergent herbicide shall be applied to ornamental shrub beds and around base of trees, in strict accordance with chemical manufacturer's printed instructions.

3.14 POST EMERGENT-HERBICIDE

A. Upon the appearance of weeds within planted areas, pre-emergent herbicide shall be applied to ornamental shrub beds and around base of trees, in strict accordance with chemical manufacturer's printed instructions.

3.15 INSECTICIDE

A. Upon the appearance of insect problems, all trunks of deciduous trees shall be sprayed with insecticide, applied as directed by chemical manufacturer.

3.16 STAKING AND GUYING

A. Each tree shall be staked or guyed immediately following planting. All evergreen trees and deciduous trees over 4" caliper shall be guyed. Plants shall stand vertical and plumb after staking or guying. Set vertical stakes and space to avoid penetrating root balls or root masses. Allow enough slack to avoid rigid restraint of tree. Stakes and guys shall be installed as indicated on the Drawings.

3.17 MULCHING

A. Mulch shall be applied as follows (entire area listed shall be mulched):

Plant Type	Mulch Area	Mulch Depth, in.
Tree	Saucer	1
Shrub	Saucer or Bed	1
Ground Cover	Bed	1

B. Mulch shall not be allowed to cover the base of trunks.

3.18 PRUNING

A. Each tree and shrub shall be pruned to preserve the natural character of the plant. Pruning shall be done after delivery of plants and after plants have been inspected and approved by the Architect. Pruning procedures shall be reviewed with Architect before proceeding.

B. Pruning shall be done with clean, sharp tools. Cuts shall be made flush, leaving no stubs. No tree paint shall be used.

C. Dead wood, suckers, and broken, weak, interfering and badly bruised branches shall be removed.

3.19 MAINTENANCE OF PLANTING

A. Maintenance shall begin immediately after each plant is planted and shall continue until Final Acceptance.

B. Maintenance shall consist of pruning, watering, cultivating, weeding, mulching, fertilizing, removal of dead material, repairing and replacing of tree stakes, tightening and repairing of guys, adjusting and replacing of damaged tree wrap material, resetting plants to proper grades and upright position, and furnishing and applying such sprays as are necessary to keep plantings free of insects and disease, and in a healthy growing condition.

C. Daily watering of 1 gal./caliper inch should be delivered to the root ball of each tree during the first summer after planting. Continue through fall, reducing frequency. For trees larger than 3 inch caliper, fill saucer with 6 – 8 gallons twice per week during hot, dry weather, and once per week during cooler, wetter periods.

D. Planting areas shall be kept free of weeds, grass, and other undesired vegetative growth.

END OF SECTION

SECTION 32 94 00
BIORETENTION

PART 1-GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.2 DESCRIPTION OF WORK

A. Work Includes: Provide labor, materials, tools, and equipment required to complete the work as indicated on the Drawings and as specified within this section. The work shall include the installation of the bioretention areas as shown on the Drawings. Work shall include all excavation, soil media, aggregate media, grading, backfill, compaction, loaming, seeding, erosion control protection, outlet structures, and the stabilization of the bioretention area. Work shall be completed and coordinated with connecting storm drainage improvements as required in other specification sections.

1.3 RELATED WORK

A. Work Included: Provide labor, materials, and equipment necessary to complete the work of this Section, including but not limited to the following:

1. Install all materials specified for the bioretention areas.

B. Related Work: The following items are noted and included in this Section and will be performed under the designated sections:

1. Section 31 10 00 – SITE CLEARING
2. Section 31 20 00 – EARTH MOVING
3. Section 31 25 00 – EROSION AND SEDIMENTATION CONTROLS
4. Section 32 90 00 – PLANTING
5. Section 32 93 00 – TURF AND GRASSES
6. Section 33 40 00 – STORM DRAINAGE UTILITIES

1.4 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

1. Qualification Data: For qualified landscape Installer.
2. Shop Drawings: Shop drawings showing dimensions, joint and other details of all materials proposed for the work. Shop drawings shall be submitted to the Designer for approval prior to ordering material.
3. Product Samples: For bioretention planting soil, sand, pea gravel, and crushed stone. Samples shall be provided in a sealable bag, minimum 6-inches x 6-inches in size.
4. Material Test Reports: For bioretention planting soil, topsoil, borrows, and aggregates. Sieve, pH, salt content, others as described below.
5. Bioretention Planting Soil and Sand Layer infiltration test results.
6. Bioretention Area Installation, Seeding and Planting Schedule: Indicating anticipated installation, seeding and planting dates for each type of planting.

7. Maintenance Instructions: Recommended procedures to be established by Landscape Contractor for maintenance of turf and plantings during a calendar year. Submit before expiration of required maintenance periods

1.5 DEFINITIONS

A. Finish Grade: Elevation of finished surface of bioretention planting soil.

B. Bioretention Planting Soil: Soil mixed offsite by blending mineral soils with sand and stabilized organic soil amendments resulting in a homogeneous planting soil for bioretention areas.

C. Topsoil: Standard topsoil; existing, native surface topsoil; existing, in-place surface soil; imported topsoil; or manufactured topsoil that is modified with soil amendments and fertilizers to produce a soil mixture suitable for plant growth.

D. Subgrade: Surface or elevation of subsoil remaining after excavation is complete or top surface of a fill or backfill before bioretention materials are placed.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful stormwater management installation. Require Installer to maintain an experienced full-time supervisor on Project site when construction, seeding, and planting is in progress.

B. Soil-Testing Laboratory Qualifications: An independent laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.

C. Bioretention Soil Analysis: Furnish soil analysis by a qualified soil-testing laboratory stating percentages of organic matter; gradation and percentages of sand, silt, and clay content; soluble salts; pH; and mineral and plant-nutrient content of soil, including magnesium, phosphorous, and potassium. All bioretention areas shall have a minimum of one test unless directed otherwise by the Designer.

D. Topsoil Suitability: Report suitability of topsoil for turf growth. State recommended quantities of nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory topsoil.

E. All plant material shall conform, in all respects, to the guidelines of the “American Standard for Nursery Stock”, latest edition, published by the American Nursery & Landscape Association, Inc. and shall have been grown under climatic conditions similar to those in the locality of the project for at least 2 years.

F. Pre-Construction Conference: Conduct conference at Project site to comply with requirements of these specifications.

G. Mandatory construction inspections as specified in the Drawings.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Soil, borrow, and aggregate materials: Deliver soil, borrows, aggregates, and other bioretention materials to a pre-approved location in separate piles. Stockpiled left for an extended period (over a week) shall be surrounded by containment straw bales and completely covered with an approved blanket material to prevent invasive seed contamination from mixing with the stockpiled materials.

B. Seed: Deliver seed in original sealed, labeled, and undamaged containers.

C. Plants shall be delivered only after preparations for planting has been completed. They shall be planted immediately upon arrival at the site. If planting is delayed more than 6 hours after delivery, the plants must be properly maintained and watered by the Contractor.

1.8 PROJECT CONDITIONS

A. Bioretention Installation: Bioretention installation shall occur during one of the following periods. Coordinate bioretention installation periods with planting periods and initial maintenance periods to provide required maintenance from date of Substantial Completion.

1. Spring Planting: April 1 to June 1.
2. Fall Planting: August 15 to October 15.

B. Weather Limitations: Proceed with bioretention installation only when existing and forecasted weather conditions permit.

1.9 MAINTENANCE SERVICE

A. Initial Maintenance Service: Provide full maintenance by skilled employees of the Landscape Contractor until Substantial Completion.

PART 2-PRODUCTS

2.1 BIORETENTION MATERIALS

A. The following specifications set forth the required characteristics for materials used in bioretention facilities.

2.2 BIORETENTION SOIL

A. Bioretention Planting Soil shall be a uniform mix and consist of loose, friable soil, free of ice, snow, and rubbish with no foreign matter, or material harmful to plant growth. Soil shall be reasonably free of stones, stumps, lumps, roots, and weeds or similar objects larger than 1-inch in diameter. No other materials or substances shall be mixed or dumped within the bioretention area that may be harmful to plant growth or prove a hindrance to the planting or maintenance operations.

B. Bioretention Planting Soil shall be a mixture of sand, compost, and topsoil to the following approximate proportions by volume: 40% Sand, 20-30% topsoil, and 30-40% compost. Compost, sand, and topsoil materials shall be as specified herein.

C. The Bioretention Planting Soil mixture shall be tested and meet the following criteria:

Textural Class	**Percent of Total Weight**
Gravel (greater than 2 mm)	< 15%
Sand (0.05-2.0mm diameter)	> 85%
Silt (0.002-0.05 mm diameter)	< 10%
Clay (less than 0.002 mm diameter)	< 2%

D. The final Bioretention Planting Soil mixture shall be tested and meet the following parameters:

Parameters	**Range**
pH	5.5 – 7.5
Moisture Content	25% – 55%
Organic Matter Content	4 – 7% (dry weight basis)
Stone and Debris	< 5% (by weight)
Soluble Salts	2.5 mmhos (dS)
Magnesium	Minimum 32 ppm
Phosphorus (Phosphate-P_2O_5)	Not to exceed 69 ppm
Potassium (K_2O)	Minimum 78 ppm
Foreign Matter	<.05% (by weight)

E. The Bioretention Planting Soil mixture shall be free of Knotweed, Phragmites, Purple Loosestrife, Bermuda grass, Quackgrass, Johnson grass, Mugwort, Nutsedge, Poison Ivy, Canadian Thistle, Teathumb, or other noxious weeds.

F. Topsoil: The USDA textural classification of the Topsoil for the Bioretention Planting Soil shall be LOAMY SAND or SANDY LOAM. The Topsoil shall be fertile, friable soil, uncontaminated by salt water, foreign matter, or substances harmful to plant growth. There should be no course fragments over 1-inch in size. The soil shall have at least 4 percent organic matter but not more than 8 percent on a dry weight basis, soil moisture content less than 8% by weight for installation, and a pH range between 5.5 to 6.5. The Topsoil shall be tested and meet the following criteria:

Sieve Size	**Percent Passing by Weight**
No. 10	85-100
No. 40	35-85
No. 200	10-35
<20µm	< 5

G. Processed Sand: The sand component of the Bioretention Soil shall be coarse sand that meets ASTM C-33 (Fine Aggregate) with a Fines Modulus Index of 2.75 or greater and shall conform to the following gradation:

Sieve Size	Percent Passing by Weight
3/8-inch	100
No. 4	95-100
No. 8	80-100
No. 16	50-85
No. 30	25-60
No. 50	10-30
No. 100	2-10

H. The leaf compost shall be a homogeneous and friable mixture of partially decomposed organic matter, with or without soil, resulting from the composting of yard waste in accordance with MassDEP Guidelines. The compost shall not contain biosolids. The product shall be well composted and contain material of a general humus nature capable of sustaining growth of vegetation, with no materials harmful to plant growth. Compost shall have the following properties:

Parameters	Range
pH	5.5 – 8.0
Moisture Content	35% – 55%
Soluble Salts	4.0 mmhos (dS)
C:N ratio	10 – 30:1
Particle Size	< 3/4″
Organic Matter Content	> 25%
Bulk Density	< 1400 lbs./cubic yard
Foreign Matter	< 1% (dry weight)

I. Upon approval of the topsoil, processed sand, and compost components, the approved samples shall be tested by the Owner's testing agent to provide recommendations for the correct ratio of topsoil, sand, and compost materials for the bioretention planting soil. The ratio of topsoil, sand, and compost will be based on laboratory testing and performance guidelines established by these specifications.

J. The Contractor shall blend the bioretention soil components at the ratios recommended by the testing laboratory.

K. The bioretention ratio mix, prepared and mixed by the Contractor, shall be reviewed by the Owner's testing agent who will review and adjust the required mix ratio and specifications for approval or rejection of all quality control submittals during construction. The

Contractor shall bear the cost of all bioretention soil mixing for the testing agent and bear the cost of all testing by the Owner's testing agent.

L. Testing Methods

1. ASTM F1632-B Standard Test Method for Particle-Sized Distribution (Gradation) of Soils Using Sieve Analysis shall be used for measurement of particle size distribution and coefficient of uniformity.
2. Performance Testing: ASTM F1815 Standard Test Method for Saturated Hydraulic Conductivity shall be used to determine infiltration rate.

M. The infiltration rate of the Bioretention Planting Soil Layer within the bioretention areas after installation shall be between 4 in/hr. and 10 in/hr.

N. Should the pH fall outside of the acceptable range, the Bioretention Planting Soil may be modified with lime (to raise) or iron sulfate plus sulfur (to lower). The lime or iron sulfate must be mixed uniformly into the Bioretention Planting Soil prior to use in bioretention facilities.

O. Should the Bioretention Planting Soil not meet the minimum requirement for magnesium, it may be modified with magnesium sulfate. Likewise, should the Bioretention Planting Soil not meet the minimum requirement for potassium, it may be modified with potash. Magnesium sulfate and potash must be mixed uniformly into the Bioretention Planting Soil prior to use in bioretention facilities.

P. Planting soil and/or Bioretention Planting Soil that fails to meet the minimum requirements shall be replaced at no additional cost to Owner. Mixing of the corrective additives to the Bioretention Planting Soil is incidental and shall be at no additional cost to the Owner.

Q. Mixing of the Bioretention Planting Soil to a homogeneous consistency shall be done to the satisfaction of the Designer. Upon approval of all requirements and testing above, the Bioretention Planting Soil shall be stockpiled, and no material shall be added to the Bioretention Planting Soil in the stockpile or during transport to the bioretention facility. If the Bioretention Planting Soil stockpiles are not placed in the Bioretention Basins within 30 days from the time of the testing, then the stockpile shall be retested. If the Bioretention Planting Soil no longer meets the requirements indicated above, then the Contractor shall provide the necessary additives to bring the soil back into compliance.

R. All testing should be performed by the same testing facility to maintain consistent results. The soil sample test results must be submitted and approved by the Designer prior to delivery to the Project site.

2.3 COARSE SAND

A. The infiltration rate of the Sand Filter layer within the bioretention areas after installation shall be 8 in/hr. or greater.

B. The sand filter layer shall consist of clean inert, hard, durable grains of quartz or other hard durable rock, free from clay, organics, surface coatings or other deleterious material. Sand shall meet ASTM C-33 (Fine Aggregate), with a Fines Modulus Index of 2.75 or greater and shall conform to the following gradation:

Sieve Size	Percent Passing by Weight
3/8-inch	100
No. 4	95-100
No. 8	80-100
No. 16	50-85
No. 30	25-60
No. 50	10-30
No. 100	2-10

2.4 PEA GRAVEL

A. Pea gravel shall be placed over the underdrain crushed stone. Pea gravel shall consist of durable crushed rock or durable crushed gravel stone free from ice and snow, sand, clay, loam, or other deleterious or organic material. The peas gravel shall be double washed and shall be ¼ to 3/8 inch in size or equivalent to #9 double washed crushed stone.

2.5 CRUSHED STONE

A. The crushed stone to be placed around the underdrain piping shall be clean double-washed crushed aggregate, free of rock dust, fines or soil particles. Crushed stone shall consist of durable crushed rock or durable crushed gravel stone, free from ice and snow, sand, clay, loam, or other deleterious or organic material. The crushed stone shall be uniformly blended and shall conform to the following requirements:

Sieve Size	Percent Passing by Weight
1-inch	100
¾-inch	90-100
½-inch	10-50
3/8-inch	0-20
No. 4	0-5

2.6 UNDERDRAIN PIPING

A. Underdrain piping shall be used in the drainage stone layer of the bioretention facilities as indicated on the plans.

B. Clean out pipes must be provided where indicated on the plans. Cleanouts shall consist of non-perforated Schedule 40 PVC pipe, PVC elbow, cap, and all associated fittings. Extend cleanout pipes to surface with securable cap. The top of the cap shall be 3 inches above the bioretention basin surface.

C. Underdrain piping shall conform to the following specifications:

PIPE	STANDARD	PERFORATIONS
4" Corrugated Polyethylene Pipe	ASTM F405 (Pipe Requirements) ASTM F405 (Joints and Fittings) ASTM D3350 (Material Properties) ASTM D2321 (Installation)	0.875" X 0.120" slots located in the outside valleys of the corrugations
4" PVC Sewer and Drain Pipe	ASTM D2729 (Pipe Requirements) ASTM D2321 and ASTM F1668 (Installation)	1/2" holes @ 5" on center, located at the 4- and 8- o'clock position of the installed pipe

2.7 DRAINAGE FABRIC GEOTEXTILE FOR TEMPORARY SOIL PROTECTION

A. Filter fabric shall be used to temporarily cover the installed bioretention material layers to prevent siltation from other construction until the next material layer is placed. The fabric is to be removed prior to the placement of the next material.

B. Drainage filter fabric shall meet the following Minimum Average Roll Value (MARV) specifications across the weave:

PROPERTY	TEST METHOD	REQUIREMENT	PROPERTY	TEST METHOD	REQUIREMENT
Grab Tensile Strength	ASTM D4632	120 lb. min.	Apparent Opening Size	ASTM D4751	70 US Sieve
Grab Tensile Elongation	ASTM D4632	50% max.	UV Resistance	ASTM D4335	70% at 500 hrs. min.
Trapezoidal Tear Strength	ASTM D4533	50 lb. min.	Permittivity	ASTM D4491	1.8 sec^{-1}
CBR Puncture Strength	ASTM D6241	300 lb. min.	Flow Rate	ASTM D4491	135 gal/min/ft.2 min.

PART 3-EXECUTION

3.1 COORDINATION

A. Pre-Installation Examination Required: The Contractor shall examine previous work, related work, and conditions under which this work is to be performed and shall notify the Owner in writing of all deficiencies and conditions detrimental to the proper completion of this work. Beginning work means the Contractor accepts substrates, previous work, and conditions. The Contractor shall not place any bioretention materials including the bioretention planting soil until all work in adjacent areas is complete and approved by the Owner.

B. The Designer shall review the subgrade for conditions that warrant the installation of an impervious membrane.

C. Coordinate activities with other project contractors so that there is no soil disturbance from traffic or other construction activities subsequent to placement.

D. Excavate and install underdrainage system after downstream storm drainage system has been installed to facilitate ease of subsurface connections. Protect gravel and underdrainage perforated piping from construction sediment by temporarily covering gravel/piping with filter fabric.

E. Schedule and coordinate bioretention basin soil installation with placement of Planting Soils in adjacent areas.

F. Restrict all additional traffic other than installation from retention areas prior, during, and after installation.

3.2 EXCAVATION AND COMPACTION

A. Compaction of the bioretention areas shall be avoided prior to construction. Place barricades to restrict access to the areas.

B. Do not work the soil when it is too moist or frozen. If the soil smears when worked, it is too moist.

C. The subgrade shall be nearly level with a gradient less than ½ (0.5) percent.

D. Subsoil compaction at the base of the bioretention facility shall be alleviated using primary tilling equipment such as a chisel plow, ripper, or subsoiler. Tilling operations shall be used to refracture the sub-grade to a depth of 12 inches.

E. Do not use heavy equipment within the bioretention basin. Heavy equipment can be used around the perimeter of the basin to supply materials. Grade bioretention materials with light equipment such as a compact loader or a loader with marsh tracks.

F. It is very important to minimize compaction of both the base of the bioretention area and the required backfill materials. When possible, use excavation hoes to remove original soil. If bioretention area is excavated using a loader, the contractor should use wide track or marsh track equipment or light equipment with turf type tires. Use of equipment with narrow tracks or narrow tires, rubber tires with large lugs, or high-pressure tires will cause excessive compaction resulting in reduced infiltration rates and storage volumes and is not acceptable. Compaction will significantly contribute to failure of the basin after installation.

3.3 BIORETENTION CONSTRUCTION

A. The following is the construction sequence required for proper installation of the bioretention basin. These steps may be modified with the approval of the Designer prior to the start of construction.

1. The Contractor shall conduct a preconstruction meeting with the Designer to review the installation requirements for the proposed bioretention area.
2. Clear and grub the proposed bioretention area.
3. Rough grade the bioretention area and excavate the bioretention facilities to within 1 foot of underdrain bottom.
4. Excavators or backhoes shall work from the sides to excavate the bioretention area to its appropriate design depth and dimensions. Excavating equipment shall have arms with adequate reach so they do not work in the footprint of the bioretention area. If applicable and per the Designer's direction the contractors shall utilize a cell construction approach in larger bioretention basins, whereby the basin is split into 500 to 1000 square foot temporary cells with a 10 to 15-foot earth bridge in between so that cells can be excavated from the side.
5. Any pretreatment cells and/or sediment forebays shall be excavated first and sealed to trap sediments.
6. All finish grading and stabilization for the contributing drainage area must be complete prior to beginning the final construction phase of the bioretention basin.
7. Install any temporary erosion and sediment controls to divert stormwater away from the bioretention area during final construction and until it is completed. Special protection measures such as erosion control fabrics may be needed to protect vulnerable side slopes from erosion during the construction process.
8. Excavate the bioretention facility to the bottom elevation of the crushed stone layer.
9. If infiltration is promoted then the Contractor shall rip the bottom soils to a depth of six inches to promote greater infiltration.
10. After excavation of the basin bed is complete and preparation of the subgrade meets specifications, install the specified crushed stone in the bottom of the basin prior to underdrain pipe placement.
11. Install underdrain, including 4-inch perforated pipe and crushed stone as indicated on the Drawings.
12. Install pea gravel layer and sand layer as indicated on the Drawings.
13. Deliver approved Bioretention Planting Soil and store on adjacent impervious area or plastic sheeting.
14. Backfill with approved Bioretention Planting Soil to the design grade (un-compacted) as specified on the Drawings. Apply in 6-inch lifts until desired top elevation of bioretention is achieved. Wait 3 days to check for settlement, and add additional media as needed.
15. Stabilize all remaining disturbed areas and side slopes with seeding, hydroseeding, and/or erosion control blankets.
16. Seed bioretention basin as specified on the Drawings and water the seed during weeks of no rain for the first two months.
17. No seeding shall occur before the remaining disturbed areas surrounding the facility are stabilized.

18. The Contractor will be required to remove any sediment that washes into the bioretention basin during the construction and planting phases. If suitable vegetative cover has not been established along the bioretention basin slopes prior to seeding, a silt fence perimeter shall be installed at the toe of the bioretention basin slopes and remain in place until an approved vegetative cover has been established.
19. Conduct final construction inspection with Designer.
20. Remove remaining erosion and sediment controls only after surrounding disturbed areas have been properly stabilized.

B. Perforated Pipe Installation:

1. The main collector pipe for underdrain systems shall be constructed with a slope between 0.25 to 1.0%. All piping shall be of uniform gradient and provide unrestricted flow to the outlet.
2. Perforated pipe shall be placed with the perforations down at 4 and 8 o'clock positions (PVC pipe).
3. The ends of underdrain pipes without a cleanout shall be capped.
4. Place the remaining specified crushed stone to a depth of 12 inches.
5. Temporarily cover the crushed stone surface with fabric to prevent sedimentation of the gravel layer prior to the placement of the pea gravel layer. The fabric is to be removed prior to pea gravel layer placement.

C. Pea Gravel Installation: Place the pea gravel to a depth of 4 inches.

D. Sand and Bioretention Planting Soil Installation: Never work bioretention planting soil when wet or frozen.

1. The Bioretention Planting Soil media shall be homogenous. Soils that have visible lumps of material or coarse fragments (rocks) greater than 2.5 cm (1-inch) is cause for rejection.
2. The sand and bioretention planting soil shall be placed in 6-inch lifts. Installation traffic is allowed to spread and "seat" the soil, but additional soil compaction is strictly forbidden. Do not use heavy equipment within the bioretention facility.
3. Scarify the surface of each lift to prevent compaction interfaces that will reduce the functionality of the retention basin.
4. Test infiltration rates of completed Sand Filter layer and submit results to the Designer. Determine permeability of the layer using a single ring infiltrometer method after it has been scarified. Gain approval of Sand Filter layer installation infiltration prior to placement of the Bioretention Planting Soil layer. At the completion of the Bioretention Planting Soil layer prior to plant and seed placement, test the infiltration rate and submit to the Designer.
5. Heavy equipment can deliver bioretention materials to the basin from outside of the bioretention area.
6. Grade bioretention materials with light equipment such as a tracked skid-steer or a dozer/loader with marsh tracks.
7. Back blading of the soil with buckets or doze blades is strictly forbidden.
8. Volume of bioretention planting soil media shall be at least 110% of plan volume to account for settling and compactions.
9. The bioretention planting soil media shall be saturated with water to settle the media before the final lift so that it can be adjusted in the field to correspond to the plan

elevations. The water to saturate the placed bioretention planting soil shall either be provided by the Contractor or from a rain event capable of saturating the soil.

10. No other materials or substances shall be mixed or dumped within the bioretention area that may be harmful to plant growth or prove a hindrance to the planting or maintenance operations.

3.4 SEEDING

A. Grass seed should be tilled into the Bioretention Planting Soil to a depth of at least one inch. Maintenance shall begin immediately after the bioretention basin is seeded and the Contractor shall be responsible for maintenance of the lawn including watering, weeding, fertilization, mowing and reseeding as necessary to establish a uniform stand of the specified grasses and until final acceptance. Scattered bare spots, none of which are larger than 72 square inches, will be allowed in seeded areas up to a maximum of 2 percent of the bioretention basin area. After the grass has started, all areas and parts of areas, which fail to show a uniform stand of grass, for any reason whatsoever, shall be reseeded and such areas and parts of areas shall be reseeded repeatedly until all areas are covered with a satisfactory growth of grass. At time of first cutting, keep mower blades not less than 2 1/2 inches high. Contractor is responsible for lawn maintenance until final acceptance or two cuttings, whichever is longer.

B. Prior to acceptance, any damage resulting from erosion, gulleys, washouts or other causes shall be repaired by filling with supplemental bioretention planting soil, tamping and reseeding.

C. If the grass stand is unsatisfactory, the Landscape Contractor's maintenance responsibility shall continue, including a normal program of mowing, until an acceptable stand of grass is achieved.

3.5 PLANTING

A. The plant root ball should be planted so 1/8th of the ball is above final grade surface. Root stock of the plant material should be kept moist during transport and on-site storage. The diameter of the planting pit should be at least six inches larger than the diameter of the planting ball. Set and maintain the plant straight during the entire planting process. Thoroughly water ground bed cover after installation.

B. Trees should be braced using 2 in x 2 in stakes only as necessary and for the first growing season only. Stakes are to be equally spaced on the outside of the tree ball.

C. Grasses and legume plugs should be planted following the non-grass ground cover planting specifications.

D. Plants shall be guaranteed for a period of one (1) year after the initial acceptance, and shall be alive and showing satisfactory growth at the end of the guarantee period. The sum of 10% of the total cost of the planting contract shall be retained and paid to the Contractor after replacements have been made, one year from acceptance of the original planting.

E. The Owner will be responsible for the maintenance of the new plantings beginning at the date of the initial acceptance and continuing through the guarantee period. At the end of the guarantee period, the Contractor shall request, in writing, a final inspection from the Landscape Architect. At this time, all plants shall be alive and in normal healthy condition. All plants shall show 75% healthy growth and shall have the natural character of a plant of its species in accordance with the American Nurserymen's Association standards. Dead or unsatisfactory plants shall be removed and replaced by the Contractor during the normal

planting season. A final inspection for acceptance will be made after the replacements have lived through one year.

F. All replacements shall be of the same kind and size specified on the plant list or as approved by the Landscape Architect. The cost shall be borne by the Contractor, except for possible replacements due to vandalism or neglect on the part of others.

3.6 PROTECTION AND REPAIRS

A. During bioretention area construction, protect partially finished soil installation with weighted plastic tarps during heavy precipitation events until protective vegetation has been placed and established.

B. Bioretention areas shall be fully protected by silt fence or construction fencing or as shown in the Drawings during the entire construction period and until the site drainage area to the bioretention area is properly stabilized. Erosion control measures shall include at a minimum silt fence, straw bales, and erosion netting on the surfaces of bare soil surrounding the bioretention basins until vegetation is established. When possible, the bioretention area shall remain outside the limit of disturbance during construction to prevent soil compaction by heavy equipment.

C. If blowing of material is a concern, a biodegradable netting can be spread over the surface until the facility has gone through several wetting cycles.

D. Bioretention Area Protections shall be maintained until the surrounding surface areas have been fully stabilized throughout the entire vegetation establishment period and as approved by the Designer.

E. Vegetate the surrounding catchment areas as quickly as possible.

F. Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash, debris or construction materials.

G. Repair, reshape and re-establish finished grades where areas settle, erode, are disturbed or damaged.

H. Refer to Section 32 90 00-Planting and Section 32 92 00 – Turf and Grasses for coordination of protection measures between retention construction and planting soil installation.

3.7 INSPECTION AND MAINTENANCE

A. After construction, monthly inspection of the bioretention facilities shall be conducted until the plants are established and the vegetative cover is 90% or greater.

B. The Contractor shall provide water to establish the seeding and/or plantings within the bioretention area.

C. Remove all visible accumulations of sediment on top of the vegetated surface with a flat shovel. Stabilize eroded areas with appropriate geotextile and replant as required to establish growth.

D. Check for sediment at inflow points including curb cuts, gravel filter strips, and/or pavement edges. Remove sediment as necessary.

E. Inspect side slopes and adjacent grass areas for erosion gullies and repair as necessary.

3.8 CLEAN UP

A. At the completion of the work, the Contractor shall remove all debris, materials, rubbish, excess dirt, etc., from the site and legally dispose of them in a manner satisfactory to the Designer. Contractor shall leave the premises in a clean, safe, and satisfactory condition. The contractor shall be responsible for any costs incurred in this process.

End of Section

SECTION 33 05 05
SELECTIVE SITE UTILITY DEMOLITION

PART 1 – GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all SECTIONS within DIVISION 1 – GENERAL REQUIREMENTS, which are hereby made a part of this section of Specifications.

1.2 DESCRIPTION OF WORK

A. Work Included: Provide labor, materials, and equipment necessary to complete the work of this Section, including but not limited to the following:

1. Protection of Existing Utilities.
2. Utility Demolition as required to accommodate new construction, including demolition of Phase I Site Enabling Utilities.
3. Protection and Abandonment of Utilities

B. Related Work: The following items are not included in this Section and will be performed under the designated Sections:

1. Section 310000 – EARTHWORK for soil materials, excavating, backfilling, and site grading and removal of site utilities.
2. Section 312500 – SEDIMENTATION AND EROSION CONTROL for required erosion and sedimentation control measures.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

1. Schedule indicating proposed sequence of operations for demolition work for review prior to start of work. Include coordination for shutoff, capping, and continuation of utility services as required, together with details for dust and noise protection.

a. Provide detailed sequence of demolition and removal work to ensure uninterrupted progress of Owner’s on-site operations.
b. Coordinate with Owner's continuing occupation of portions of existing building, adjacent buildings, and with Owner's partial occupancy of completed portions of proposed building or additions.

2. Preconstruction survey photographs of existing conditions of structure surfaces, equipment, and adjacent improvements that might be misconstrued as damage related to removal operations are recommended. File with Owner's Representative prior to start of work.

1.4 EXAMINATION OF SITE AND DOCUMENTS

A. It is hereby understood that the Contractor has carefully examined the site and all conditions affecting work under this Section. No claim for additional costs will be allowed because of a lack of knowledge of existing conditions as indicated in the Contract Documents, or obvious from observation of the site.

B. Plans, surveys, measurements, and dimensions under which the work is to be performed are believed to be correct, but the Contractor shall have examined them for himself during the bidding period and formed his own conclusions as to the full requirements of the work involved.

PART 2 – PRODUCTS

(Not applicable to work of this section.)

PART 3 – EXECUTION

3.1 DISPOSAL OF WASTE MATERIALS

A. Removal from Owner's Property: Remove waste materials offsite in a legal manner.

3.2 SITE UTILITIES

A. Locate, identify, disconnect, and seal or cap off utilities indicated to be removed.

1. Arrange with utility companies to shut off indicated utilities. The Contractor is responsible for coordinating and scheduling with the authorities having jurisdiction the removal and/or abandonment of existing utilities as required to complete the work.

B. Existing Utilities: Do not interrupt utilities serving facilities occupied by the Owner’s Representative or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify the Owner’s Representative not less than two days in advance of proposed utility interruptions.

2. Do not proceed with utility interruptions without the Owner’s Representative’s written permission.

C. Utility pipes designated to be abandoned in place shall be plugged at their ends with watertight brick masonry or cement mortar with a minimum thickness of 8 inches.

D. Utility pipes designated to be removed shall consist of the complete removal and disposal of the entire length of pipe and backfill and compaction of the void with ordinary borrow. When the void is within the footprint of the new building, gravel borrow shall be used to backfill the void.

E. Utility structures designated to be abandoned in place shall have their cast iron castings removed and disposed, inlet and outlet pipes plugged, the bottom of the structures shall be broken, the void of the structure shall be backfilled and compacted with ordinary borrow, and the top of the structure shall be removed so that it is at least 36 inches below finished grade.

F. Utility structures designated to be removed shall consist of the removal and disposal of cast iron castings, plugging of inlet and outlet pipes, removal of the structure, and backfill and compaction of the void with ordinary borrow. When the void is within the footprint of the new building, gravel borrow shall be used to backfill the void.

3.3 DISPOSAL, CLEANUP, AND REPAIR

A. Disposal: Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off the Owner's property.

1. Burning on site is prohibited.

2. Separate recyclable materials produced during site clearing from other nonrecyclable materials. Store or stockpile without intermixing with other materials and transport them to recycling facilities.

B. General: Upon completion of demolition work, remove tools, equipment, and demolished materials from site.

C. Repair demolition performed in excess of that required. Return elements of construction and surfaces to remain to condition existing prior to start operations. Repair adjacent construction or surfaces soiled or damaged by site utility demolition work.

End of Section

SECTION 33 10 00
WATER UTILITIES

PART 1-GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all SECTIONS within DIVISION 1 – GENERAL REQUIREMENTS, which are hereby made a part of this Section of Specifications.

1.2 DESCRIPTION OF WORK

A. Provide labor, materials, and equipment necessary to construct the exterior water system complete, including connections to existing pipelines and testing, all as indicated on the Drawings and as specified, including but not limited to the following:

1. Installation of ductile iron pipe, fittings, accessories, and appurtenant work, at the locations and to the lines and grades indicated on the Contract Drawings.
2. The installation of hydrants, gate valves and boxes and concrete thrust blocks.
3. Furnishing and installation of all materials required to connect to existing water mains, replace existing services, install new gate valves, remove existing gate valves, install corporation cocks, saddles, curb stops, service boxes, and abandoning of the existing water system (if applicable), all as shown on the Contract Drawings. All valves, 24 inches and larger shall be butterfly valves. All abandoned pipes shall be cut and capped at the main.
4. In accordance with 528 CMR 11.00, work on the fire protection system, including hydrants and exterior underground piping, shall be performed by a Licensed Fire Protection Sprinkler Systems Contractor. The fire protection exterior underground piping will terminate at the valved tee connection to the water distribution system. The tee and valve will not be considered part of the fire protection system work.
5. Work to include complete coordination with the City's separate contract to install off-site high service water line from Park Avenue up to the site including stub connections for the site fire service and water service installation under this contract.
6. Connect the existing water service to the building for temporary use (refer to Construction Manager's general conditions) and remove after new service is installed

B. Unless otherwise indicated on the Drawings, exterior water lines shall be installed from a point 10 feet outside the building foundation walls to the potable water source

C. Related Work: The following items are not included in this Section and will be performed under the designated Sections.

1. Section 312000 – EARTH MOVING for excavation, backfill, and compaction requirements.
2. Section 211000 – FIRE PROTECTION for fire protection service piping.
3. Section 221000 – PLUMBING for potable water service piping.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

1. Descriptive literature showing pipe dimensions, pipe and joint materials and dimensions, and other details for each class or type of pipe or product to be furnished for this contract. All pipe furnished under the contract shall be manufactured in accordance with these Specifications.
2. Product Data: Submit manufacturer's technical product data and installation instructions for potable water system materials and products.
3. Shop Drawings: The Contractor shall submit for review shop drawings or descriptive literature for potable water system, showing piping, fittings, couplings, valves, hydrants, materials, dimensions, restrained joint calculations, joints and other details, blocks, and anchors. All hydrants and valves furnished under the Contract shall be manufactured only in accordance with the Specifications and the approved Shop Drawings.
4. At project closeout, submit record drawings of installed potable water system piping and products, in accordance with requirements of Division 1. As-Built Drawings shall be complete and shall indicate the true measurement and location, horizontal and vertical, of all new construction. As-Built drawings shall be stamped and signed by a Massachusetts Licensed Land Surveyor or Licensed Professional Engineer. The as-built plans shall also be submitted electronically as an AutoCAD drawing file (release 2010 or higher).
5. Maintenance Data: Submit maintenance data and parts lists for water system materials and products. Include this data, product data, shop drawings, and record drawings in maintenance manual in accordance with requirements of Division 1.

1.4 REFERENCE STANDARDS

A. The following standards are applicable to the work of this Section to the extent referenced herein:

1. ASTM: American Society for Testing and Materials.
2. ANSI: American National Standards Institute.
3. AWWA: American Water Works Association.
4. AASHTO: American Association of State Highway and Transportation Officials.
5. Reference is made herein to the Commonwealth of Massachusetts, Department of Transportation (MassDOT), Formerly Massachusetts Highway Department (MHD) Standard Specifications for Highways and Bridges, latest edition, hereinafter referred to as the "Standard Specifications". All references to method of measurement, basis of payment, and payment items in the "Standard Specifications" are hereby deleted. References made to particular sections or paragraphs in the "Standard Specifications" shall include all related articles mentioned therein.
6. MassDOT, Construction Standards, latest Edition with amendments, hereinafter referred to as the “Construction Standards.”
7. Commonwealth of Massachusetts State Plumbing Code, latest edition.
8. Commonwealth of Massachusetts Regulations 528 CMR 12.00 Sprinkler Contractor Licensing Regulations.
9. City of Worcester Department of Public Works Standard Specifications and Details, February 1, 2021 or latest edition.

1.5 EXAMINATION OF SITE AND DOCUMENTS

A. It is hereby understood that the Contractor has carefully examined the site and all conditions affecting work under this Section. No claim for additional costs will be allowed because of a

lack of knowledge of existing conditions as indicated in the Contract Documents, or obvious from observation of the site.

B. Plans, surveys, measurements, and dimensions under which the work is to be performed are believed to be correct, but the Contractor shall have examined them for himself during the bidding period and formed his own conclusions as to the full requirements of the work involved.

1.6 QUALITY ASSURANCE

A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of potable water systems materials and products, of types and sizes required, whose products have been in satisfactory use in similar service for not less than five years.

B. Installer's Qualifications: Firm with at least three years of successful installation experience on projects with potable water piping work similar to that required for this project.

C. Water Purveyor Compliance: Comply with requirements of Purveyor supplying water to project, obtain required permits and inspections.

1.7 PROJECT CONDITIONS

A. Site Information: Perform site inspection and survey, research utility records, and verify existing utility locations and elevations. Verify that water system piping may be installed in compliance with Contract Drawings and referenced standards.

B. Interruption of Existing Water Distribution System: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to the requirements indicated:

1. Notify Architect no fewer than two days in advance of proposed interruption of service.
2. Do not proceed with interruption of service without Architect’s written permission.

1.8 SEQUENCING AND SCHEDULING

A. Coordinate with interior building domestic water and fire protection system piping.

B. Coordinate with other utility work.

C. The Contractor is responsible for developing a sequence of work to maintain existing services in operation until the new services are operational.

D. The Contractor is responsible for coordinating and scheduling the inspection of the work by the City of Worcester. All permits and inspection costs and fees shall be included in the bid prices and no additional costs will be paid to the Contractor.

PART 2-PRODUCTS

2.1 DUCTILE IRON PIPE AND FITTINGS

A. General: Provide piping materials and factory fabricated piping products of sizes, types, pressure ratings, and capacities as indicated. Where not indicated, provide proper selection as determined by Engineer to comply with installation requirements. Provide pipe fittings and accessories of same materials and class as pipes with joining method, as indicated. The piping shall be manufactured by an established manufacturer of good reputation in the industry and in a permanent plant adapted to meet all the design requirements of the pipe.

1. Ductile iron pipe shall be that of a manufacturer who can demonstrate at least five years of successful experience in manufacturing ductile iron pipe. The pipe shall be equipped with push on type, restrained joint, or mechanical joints, as required.
2. All ductile iron water pipe shall conform to American Water Works Association (AWWA) C150 and AWWA C151.
3. The ductile iron pipe shall be Class 52 and furnished in minimum nominal 18-foot lengths, with Push-on or Mechanical Joints as manufactured by U.S. Pipe and Foundry Company, Atlantic States Cast Iron Pipe Co., Clow Corporation, or approved equal with gaskets conforming to AWWA C111 "Rubber Gasket Joints". A minimum of two bronze wedges per joint shall be used to maintain conductivity and facilitate lock-on.
4. All ductile iron pipes shall be rated for a minimum operating pressure of 350 psi.
5. The exterior of ductile iron pipe shall be coated with a layer of arc-sprayed zinc per ISO 8179. The mass of the zinc applied shall be 200 g/m2 of pipe surface area. A finishing layer asphaltic topcoat shall be applied to the zinc. The mean dry film thickness of the finishing layer shall not be less than 3 mils. with a local minimum not less than 2 mils. The zinc coating system shall conform to ISO 8179-1 “Ductile iron pipes-External zinc-based coating-Part 1: Metallic zinc with finishing layer. Second edition 2004-06-01.”
6. The ductile iron water pipe shall be double cement lined inside and then asphalt seal coated in accordance with AWWA C104 and AWWA C151. The pipe shall be furnished along with necessary materials and equipment recommended by the manufacturer for use in joining pipe lengths and fittings.
7. All water pipe shall be encased in polyethylene film when the trench is backfilled with control density fill.
8. Fittings shall be ASTM A-536 ductile iron with mechanical joint fittings. All fittings 3 inches through 48 inches in diameter shall meet or exceed the requirements of AWWA C110. Compact fittings shall be ductile iron meeting or exceeding the requirements of AWWA C153. Fittings shall have the same lining and coating as the pipe specified above. All fittings shall be marked with the weight and shall have distinctly cast upon them the pressure rating, the manufacturer's identification, nominal diameter of openings and the number of degrees or fraction of the circle on all bends. All fittings 4 through 24 inches shall be Class 350. All fittings greater than 24 inches shall be as specified above except they shall be Class 250. Compact fittings shall only be used in sizes 4 through 24 inches. Fittings shall conform to the weights, excluding accessories, and dimension shown in the latest edition of the Handbook of Ductile Iron Pipe and come complete with all joint accessories as required. All accessories (gland, gaskets, T-bolts, and nuts) shall be in accordance with AWWA C111. All mechanical joint bolts (T-bolts) shall be Cor-Ten or equal.
9. In order to provide positive joint restraint, valve anchor tees/valves and restrained joints shall be used on fire services and on the 6-inch branch connections for hydrants.
10. Caps and plugs installed in all new work as indicated on the Contract Drawings shall be provided with a threaded corporation or bleeder valve so that air and water pressure can be relieved prior to future connection.
11. Contractor shall provide all adapters and fittings such as transition couplings, as determined in the field, necessary to complete all cross connections, whether or not specifically stated in the Contract Drawings and Specifications.
12. All pipe shall be marked with the class, thickness designation, and initials of the manufacturer.
13. If required the manufacturer shall supply the Engineer with certificates of compliance with these Specifications and certification that each piece of ductile iron pipe has been tested at the foundry with the Ball Impression Test, Ring Bending, or equal.

14. Thrust blocks shall be used at all bends and fittings as shown on the details. In addition, all bends and fittings shall be restrained with Megalug Series 1100 mechanical joint restraint. In the event that the use of thrust blocks is not practical or allowed, the Contractor shall provide an alternate method of joint restraint, at no additional cost to the owner, as approved and/or as directed by the Engineer. Restraint length calculations and restrained joint locations shall be provided by the contractor and submitted to the engineer for review. Restraint length values shall be calculated per the manufacturer's standards.
    a. Restraint for standardized mechanical joints shall be incorporated in the design of the follower gland and shall impart multiple wedging action against the pipe, increasing its resistance as the pressure increases. The assembled joint shall maintain its flexibility after burial and shall maintain its integrity by a controlled and limited expansion of each joint during the wedging action. Restraining glands shall be manufactured of high strength ductile iron conforming to the requirements of ASTM A536, Grade 65-45-12. Wedging mechanisms shall be manufactured of ductile iron, heat treated to a hardness of 370 BHN minimum. Dimensions of the gland shall be such that it can be used with the standardized mechanical joint bell and tee head bolts conforming to the requirements of ANSI/AWWA A21.11/C111 and ANSI/AWWA A21.53/C153 of latest revision. Twist-off nuts shall be incorporated in the design of the wedge activation screws to ensure proper torque. The mechanical joint restraining device shall have a water working pressure rating of 350 psi minimum (in sizes 4" thru 16") with a safety factor of at least 2:1 against separation when tested in a dead-end situation.
    b. Restraint for push-on ductile iron pipe shall consist of a wedge action restraint ring on the spigot joined to a split ductile iron ring behind the bell. The restraint ring shall have individually actuated wedges that increase their resistance to pull-out as pressure or external forces increase. The restraint ring and its wedging components shall be made of minimum grade 65-45-12 ductile iron conforming to ASTM A536. The wedges shall be heat treated to a minimum hardness of 370 BHN. Torque limiting twist off nuts shall be used to ensure proper actuation of the restraining wedges. The split ring shall be made of a minimum grade of 65-45-12 ductile iron conforming to ASTM A536. The connecting tie rods that join the two rings shall be made of low alloy steel that conforms to ANSI/AWWA C111/A21.11. The assembly shall have a rated pressure with a minimum two to one safety factor of 350 PSI in the sixteen-inch size and below 250 PSI in the eighteen through thirty-six-inch sizes. Push on joints on ductile iron pipe shall be restrained with Megalug Series 1700 restraint harness.
15. Insulation shall be manufactured by Thermal Pipe Systems, Atlas Insulation, or Insulated Piping Systems Inc., or other approved manufacturer. Insulation shall be factory foamed-in-place polyurethane foam insulation having nominal thickness of 1 1/2-inch, with an in-place density of 2.5 pcf, and a "K" factor of 0.16 BTU*in./hr.*°F*sq. ft. Straight joints between insulated pipe lengths, and the end sections of non-insulated pipe shall be sealed with heat shrinkable wrap-around polyethylene as supplied by manufacturer and installed in field by Contractor. Insulation jacket shall be 20-gauge corrugated aluminum preformed to be fastened with stainless steel screws and bands. Jacket shall have one layer of one mil polyethylene film with a protective coat of 40-pound virgin Kraft paper to act as a moisture and galvanic corrosion barrier.
16. Pipe for use with split couplings shall be as specified except that the ends shall not have bells or beads but shall have cast or machined shoulders or grooves as necessary for the couplings to be used and shall conform to the specifications of the manufacturer of the couplings. If split couplings are used with grooved ductile-iron pipe, the minimum pipe wall thickness shall be as follows:

Nominal Pipe Size (In.)	Thickness Class
4-12	53
14-18	54
20	55
24	56

17. Pipe for use with sleeve-type couplings shall be as specified except that the ends shall be plain (without bells or beads). The ends shall be cast or machined at right angles to the axis.

B. COUPLINGS AND ADAPTERS FOR DUCTILE IRON PIPE

1. Sleeve type couplings for plain end pipe shall be provided with plain rubber gaskets and steel, tee head bolts with nuts. Couplings shall be Dresser style 38 or 138, furnished preassembled, as manufactured by Dresser Industries, Inc., Smith Blair, Coupling Systems, Inc., or equal.
2. Couplings or adapters as required for connecting existing pipe to new pipe or new pipe to new pipe shall be furnished as required and designed for compatibility with the pipe and operating pressures encountered. Couplings shall be Dresser Style 162 as manufactured by Dresser Industries Inc., or equal. Flanged adapters shall be Dresser Style 128, or equal. Couplings for ductile iron to cast iron pipe shall be Style 53, and for ductile iron to transite pipe shall be style 153, as manufactured by Dresser Industries, Inc., or as manufactured by Smith Blair, Coupling Systems, Inc. or equal. Transition couplings shall be Style 162 as manufactured by Dresser Industries, Inc. or approved equal.
3. Split couplings may be used for connecting gray cast iron or ductile iron. If split couplings are used with grooved ductile iron pipe, the minimum pipe wall thickness shall be as specified. Split couplings shall be made of malleable iron and shall be suitable for use with grooved-end or shouldered-end, cast iron pipe. They shall be Victaulic couplings made by the Victaulic Company of America, Elizabeth, New Jersey; Gruvagrip couplings made by Gustin-Bacon Manufacturing Company, Kansas City, Missouri; Groove couplings made by Eastern Malleable Iron Company, Pittsburgh, Pennsylvania; or equal products.
4. Flexible Couplings: Sleeve type couplings for plain end ductile iron pipe shall be provided with plain rubber gaskets and steel, track head bolts with nuts.
5. Couplings shall be furnished pre-assembled by the manufacturer.
6. Couplings shall be given a shop coat compatible with the same outside coating as the pipe specified above.
7. All couplings shall be furnished with the pipe stop removed.
8. Couplings shall be provided with gaskets of a composition suitable for exposure to the liquid within the pipe. The gaskets shall have metallic tips to provide electrical continuity through the joint.
9. The Contractor shall provide suitable filling rings where the layout of the flanged piping is such as to necessitate their use. In materials, workmanship, facing, and drilling, such rings shall conform to the 125-pound ANSI Standard. Filling rings shall be of suitable length with nonparallel faces and corresponding drilling, if necessary, to ensure correct assembly of the adjoining piping or equipment.
10. Couplings for exposed pipe shall be of steel and shall be Dresser Style 38, Smith-Blair Style 411, Baker Allsteel, or equal. The couplings shall be provided with steel bolts and nuts.

11. At the Contractor's option, flexible connections in the piping shall be sleeve-type couplings, split couplings or mechanical joint pipe as herein specified.

C. INSPECTION, TESTS, AND ACCEPTANCE FOR DUCTILE IRON PIPE

1. All pipe delivered to the job site shall be accompanied by test reports certifying that the pipe and fittings conform to "AWWA Standard for Ductile Iron Pipe, for Water and Other Liquids" (AWWA H3) and (AWWA C151).
2. All tests shall be made in accordance with the methods prescribed by the above mentioned AWWA Standards, and the acceptance or rejection shall be based on the test results.
3. Pipe which does not conform to the requirements of this contract shall be immediately removed and replaced by the Contractor.
4. All ductile iron pipe to be installed under this Contract may be inspected at the foundry for compliance with these Specifications by an independent testing laboratory selected by the Owner. The Contractor shall require the manufacturer's cooperation in these inspections. The cost of foundry inspection of all pipe approved for this Contract, plus the cost of the inspection of a reasonable amount of disapproved pipe, will be borne by the Owner.

D. FLANGED JOINTS FOR DUCTILE IRON PIPE

1. For flanged joints, gaskets shall be ring gaskets of rubber with cloth insertion. Gaskets twelve (12)-inches in diameter and smaller shall be 1/16-inch thick, gaskets larger than twelve (12)-inch shall be 3/32-inch thick.
2. Flanged joints shall be made with bolts, bolt studs with a nut on each end, or studs with nuts where the flange is tapped. The number and size of bolts shall conform to the same ANSI Standard as the flanges. Bolts and nuts shall, except as otherwise specified or noted on the Contract Drawings, be Grade B conforming to the ASTM Standard Specification for Carbon Steel, Externally and Internally Threaded Standard Fasteners, Designation A307. Bolts and studs shall be of the same quality as machine bolts. Flanged ductile iron pipe from 3 to 48-inches in diameter shall be classified by Underwriters Laboratories Inc. in accordance with AWWA C115.

2.2 PVC WATER PIPE – NOT USED

2.3 BUTTERFLY VALVES – NOT USED

2.4 RESILIENT WEDGE GATE VALVES

A. Resilient wedge gate valves shall be iron body, resilient seated type. The valves shall be designed for 250 psi working pressure and 400 psi test pressure.

B. Valves are to have O ring seals and a nonrising stem. Valves shall have a 2-inch operating nut. Valves shall open right (clockwise)

C. Resilient gate valves shall meet the most recent version of the AWWA standard specification AWWA C509.

D. Resilient wedge valves shall have mechanical joint ends.

E. Valves shall be as manufactured by U.S. Pipe and Foundry Company Metroseal 250, American Flow Control Model AFC2500, or Mueller Resilient Wedge Gate Valves.

F. Valve boxes shall be cast iron, asphalt coated, sliding, heavy pattern type, consisting of three (3) pieces; a flanged bottom piece, a flanged top piece, and a cover with two (2) lifting holes

and the word "water" cast on the top. A minimum 6-inch overlap is required between sliding sections. The valve box shall be designed and constructed to prevent direct transmission of traffic loads to the pipe or valve. The inside diameter of boxes shall be at least 4 1/2 inches and lengths shall be as necessary to suit ground elevation. The top of the cover shall be flush with the top of the box rim. Box covers shall be round frame and cover.

G. Valves shall be connected directly to valve anchor tees at all hydrant branches.

2.5 TAPPING SLEEVES AND VALVES – NOT USED

2.6 POST INDICATOR VALVE – NOT USED

2.7 HYDRANTS

A. General: Provide Hydrants as indicated. The Hydrants shall be manufactured by an established manufacturer of good reputation in the industry and in a permanent plant adapted to meet all the design requirements of the hydrant.

1. Reuse of hydrants installed under Phase #1 (Site Enabling) is permitted.
2. Fire hydrants shall meet or exceed AWWA C-502, latest revision and shall comply with Factory Mutual Research Corporation and Underwriters' Laboratories UL 246 Standard. Rated water working pressure shall be 200 psi, test pressure shall be 400 psi.
3. The main valve closure shall be of the compression type, opening against the pressure and closing with the pressure.
4. Hydrants shall be of the breakaway type: The upper barrel shall connect to the lower barrel with a breakable traffic flange and 8 bolts and nuts. This connection shall allow 360° rotation of the upper nozzle section.
5. The main valve opening shall be 5-1/4 inch and be designed so that removal of seat, drain valve mechanism, internal rod and all working parts can be removed through top of hydrant. These parts shall be removable without disturbing the ground line joint or the nozzle section of the hydrant. The bronze seat shall be threaded into mating threads of bronze for easy field removal.
6. The draining system of the hydrant shall be bronze and activated by the main stem without use of auxiliary rod, toggles, pins, etc. The drain mechanism shall be completely closed after no more than three turns of the operating nut in the opening direction. There should be a minimum of (2) inside ports and (4) drain port outlets to the exterior of the hydrant. Drain shut off to be by direct compression closure.
7. The operating nut, main stem, coupling and main valve assembly shall be capable of withstanding input torque of 200 ft. lbs. in opening or closing directions. There shall be an internal top housing with triple O-Rings to seal operating threads from the waterway and accommodate an anti-friction washer.
8. Fire hydrants shall have 6-inch mechanical joint inlet connections to the main, two 2 ½-inch hose connections, 180-degrees apart, and one 4 ½-inch steamer connection. The hose and steamer connections shall have National Standard Thread. The standpipe shall have an 8 ½-inch minimum diameter. All nozzle caps shall be cast iron and shall be secured to the hydrant barrel with chains.
9. Hydrant shall be marked with an arrow and the word "open" to indicate the direction to turn the stem to open the hydrant. Hydrants shall open to the right (clockwise) and have a bronze operating nut that shall be pentagonal in shape, 1-1/2 inch from point to opposite flat.
10. The upper barrel shall be ductile iron with markings identifying size, model and year of manufacture. The lower barrel shall be ductile iron.

11. The hydrant shall have a minimum working pressure of 200 psi. Hydrant design shall be of positive automatic drain type to prevent freezing.
12. Hydrants shall be thoroughly cleaned and given two (2) shop or field coats of paint in accordance with AWWA C502 and the instruction of the paint manufacturer. Paint color shall be the standard hydrant color of the City of Worcester (high-visability yellow).
13. If the hydrant is delivered with the manufacturer's standard color, the hydrant shall be given one (1) matching field coat of alkyd gloss enamel. If the hydrant is delivered with no standard color, the hydrant shall be given two (2) coats of alkyd gloss enamel according to the colors specified by the City of Worcester.
14. All exposed metal surfaces will be painted.
15. Hydrant paint shall be as manufactured by Sherman-Williams, PPG Industries, Pittsburgh, PA; Koppers Company, Inc., Pittsburgh, PA; Tnemec Company, Inc. Kansas City, MO; or approved equal.
16. Alkyd gloss enamel shall be Series 54-300 by PPG; Glamortex by Koppers; 2H-Tneme by Tnemec or approved equal.
17. Hydrants shall be Kennedy Guardian K81D or equal and approved by the City of Worcester.

B. HYDRANT SAFETY FLANGE REPAIR KIT

1. Safety flange repair kits shall come complete with stem coupling, safety flange, flange gasket, replacement bolts and nuts and hydrant lubricating oil.
2. Safety flange repair kits shall be compatible with hydrant furnished.

C. HYDRANT EXTENSION KITS

1. Extension kits shall come complete with extension barrel, extension stem, stem coupling and hardware, flange, flange gasket, 8 bolts and nuts and hydrant lubricating oil.
2. Extension kits shall be compatible with hydrant furnished.

2.8 IDENTIFICATION

A. Detectable Underground Warning Tapes: Acid and alkali-resistant polyethylene plastic film warning tape, 6-inches wide by 4-mils. minimum thickness, with continuously printed caption in black letters "CAUTION - xxxxx LINE BURIED BELOW." The text and color of the tape shall be as shown in the table below. The tape shall have a metallic core encased in a protective jacket for corrosion protection and be detectable by a metal detector when the tape is buried up to 2.5-feet deep.

Color	Utility
Safety Red	Electric
High Visibility Safety Yellow	Gas, Oil, Steam
Safety Alert Orange	Telephone, Communications, Cable Television
Safety Precaution Blue	Water System, Irrigation
Safety Green	Sanitary Sewer, Storm Sewer

PART 3-EXECUTION

3.1 INSPECTION

A. General: Examine areas and conditions under which potable water system's materials and products are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Engineer.

B. The Contractor is responsible for the provisions and all test requirements specified in herein. In addition, all pipe and appurtenances may be inspected at the plant for compliance with these specifications by an independent testing laboratory.

C. All tests shall be made in accordance with the methods prescribed by the above-mentioned AWWA Standards, and the acceptance or rejection shall be based on the test results.

D. Inspection of the pipe and appurtenances may also be made after delivery. The pipe and appurtenances shall be subject to rejections at any time on account of failure to meet any of the specifications requirements, even though samples may have been accepted as satisfactory at the place of manufacture.

E. Pipe which does not conform to the requirements of this contract shall be immediately removed and replaced by the Contractor at no cost to the Owner.

3.2 HANDLING PIPE

A. The Contractor shall take care not to damage pipe by impact, bending, compression, or abrasion during handling, and installation. Joint ends of pipe especially shall be kept clean.

B. Pipe shall be stored above ground at a height no greater than 5-feet, and with even support for the pipe barrel.

C. Only nylon protected slings shall be used for handling the pipe. No hooks, chains or bare cables will be permitted.

D. Gaskets shall be shipped in cartons and stored in a clean area, away from grease, oil, heat, direct sunlight and ozone producing electric motors.

3.3 INSTALLATION OF PIPE AND PIPE FITTINGS

A. The Contractor shall provide all adapters and fittings such as transition couplings, as determined in the field, necessary to complete all cross connections, whether or not specifically stated in the Contract Drawings and Specifications.

B. Care shall be taken in loading, transportation, and unloading to prevent injury to the pipe or coatings. Pipe or fittings shall not be dropped. All pipe and fittings shall be examined before placement, and no piece shall be installed which is found to be defective. Any damage to the pipe coatings shall be repaired as directed by the Engineer or Owner’s Representative.

C. If any defective pipe is discovered after it has been placed, it shall be removed and replaced with a sound pipe in a satisfactory manner by the Contractor, at his own expense. All pipe and fittings shall be kept clean until they are used in the work, be thoroughly cleaned before placement, and when placed, shall conform to the lines and grades required. Ductile iron pipe and fittings shall be installed in accordance with requirements of AWWA Standard Specification C600 except as otherwise provided herein. A firm even bearing throughout the length of the pipe shall be constructed by compacting sand gravel borrow around the pipe and up to 18 inches above the pipe.

D. Blocking will not be permitted.

E. A minimum horizontal separation of ten (10) feet shall be maintained between and existing, proposed or relocated sewer and the new water main. The distance shall be measured edge to edge. In cases where it is not practical to maintain a ten-foot separation, it is permitted to install a water main closer to a sewer, provided that the water main is laid in a separate trench or on an undisturbed earth shelf located eighteen (18) inches above the top of sewer. Where the horizontal clearance is less than ten (10) feet or the vertical clearance is less than eighteen (18) inches and the sewer crosses under the water main, both water main and sewer main shall be constructed of mechanical joint cement lined ductile iron pipe for 10-feet on either side of the crossing. One (1) full length of water pipe shall be centered over the sewer at the crossing. If the sewer crosses over the water main, regardless of the vertical separation, both pipes shall be concrete encased for a distance of ten (10) feet to either side of the respective centerline.

F. Provide minimum cover over piping of 5-feet below finished grade.

G. Extend water systems from the water main located within the public way and terminate potable water piping 10-feet 0-inches from the building foundation. Provide temporary pipe plug for piping extension into building if required by construction progress.

H. All pipes shall be sound and clean before placement. When pipe laying is not in progress, including lunchtime, the open ends of the pipe shall be temporarily closed by watertight plug or other acceptable means. Alignment shall be maintained during placement. The deflection at joints shall not exceed sixty percent of that recommended by the manufacturer. Fittings, in addition to those shown on the plans, shall be provided, if required, in crossing utilities, which may be encountered upon opening the trench. Solid sleeves shall be used only where allowed by the Engineer.

I. When cutting pipe is required, the cutting shall be done by machine, leaving a smooth cut at right angles to the axis of the pipe. Cut ends of pipe to be used with a push-on type bell shall be beveled to conform to the manufactured spigot end. Cement lining shall be inspected for damage and shall be re-mortared as required to ensure a continuous lining.

J. Mechanical joint restraints shall be used for all valves, bends, hydrants and piping section less than 50 feet. The contractor shall restrain all pipe runs to the lengths indicated on the approved restrained joint calculation shop drawings.

K. Jointing of ductile iron push on pipe and fittings shall be done in accordance with the printed recommendations of the manufacturer and as specified. The last 8 inches of the outside of the spigot end of pipe and the inside of the bell end of pipe shall be thoroughly cleaned. The joint surfaces and the gasket shall be painted with a lubricant just prior to making up the joint. The spigot end shall then be gently pushed home into the bell. The position of the gasket shall be checked to ensure that the joint has been properly made and is watertight. Care shall be taken not to exceed the manufacturer's recommended maximum deflection allowed for each joint.

1. Jointing Ductile Iron Pipe (Push-On Type): Push-on joints shall be made in strict accordance with the manufacturer's instructions. Pipe shall be laid with bell ends looking ahead. A rubber gasket shall be inserted in the groove of the bell end of the pipe, and the joint surfaces cleaned and lubricated. The plain end of the pipe to be entered shall then be inserted in alignment with the bell of the pipe to which it is to be joined, and pushed home with a jack or by other means. After joining the pipe, a metal feeler shall be used to make certain that the rubber gasket is correctly located.

2. Jointing Mechanical Joint Fittings: Mechanical joints at valves, fittings, and where designated shall be installed in accordance with the "Notes on Method of Installation" under ANSI Specification A 21.11 and the instructions of the manufacturer. To assemble the joints in the field, the Contractor shall thoroughly clean the joint surfaces and rubber gasket with soapy water before tightening the bolts. Bolts shall be tight to the specified torque. Under no condition shall extension wrenches or pipes over handles or ordinary ratchet wrenches be used to secure greater leverage.

L. Installation and jointing of ductile iron pipe shall be in accordance with AWWA C600, Sections 9b and 9c, latest revision, as applicable.

M. Service tubing shall be installed with minimum 6-inches of sand bedding and 12-inches sand cover. Service tubing shall have a minimum total cover of 5 feet.

3.4 INSTALLATION OF VALVES AND APPURTENANCES

A. Cleaning and Prime Coating Valves and Appurtenances (Except Epoxy Coated Valves)

1. Prior to shop prime coating, all surfaces of the valves and appurtenances shall be thoroughly clean, dry, and free from all mill-scale, rust, grease, dirt, paint and other foreign substances to the satisfaction of the Engineer or Owner’s Representative.
2. All ferrous surfaces shall be sand blasted or pickled according to SSPC-SP6 or SSPC-SP8, respectively.
3. All gears, bearing surfaces and other surfaces not to be painted shall be given a heavy coat of grease or other suitable rust resistant coating unless otherwise specified herein. This coating shall be maintained as required to prevent corrosion during any period of storage and installation and shall be satisfactory through the time of final acceptance.

B. Installation

1. All valves and appurtenances shall be installed in the location shown, true to alignment and rigidly supported. Any damage to the above items shall be repaired before they are installed.
2. Care shall be taken to prevent damage to valves and appurtenances during handling and installation. All materials shall be carefully inspected for defects in workmanship and materials, all debris and foreign material cleaned out of valve openings, etc., and all operating mechanisms operated to check their proper functioning, and all nuts and bolts checked for tightness. Valves and other equipment that does not operate easily, or are otherwise defective, shall be repaired or replaced.

C. Shop Painting Valves and Appurtenances

1. Interior and exterior surfaces of all valves which are not factory epoxy coated shall be given two coats of shop finish of an asphalt varnish conforming to AWWA C504 for Varnish Asphalt. The pipe connection openings shall be capped to prevent the entry of foreign matter prior to installation.

D. Buried Valves

1. Install valves as indicated with stems pointing up. Provide valve box over underground valves. Buried valves and boxes shall be set with the operating stem vertically aligned in the center of the valve box. Valves shall be set on a firm foundation and supported by tamping selected excavated material under and at the sides of the valve.

E. Valve Boxes

1. Valve boxes shall be installed vertically, centered over the operating nut, and if they are within the limits of the roadway or within limits where the plowing of snow will take place

in the winter, the tops of the boxes shall be set ½" below the top of the finished grade. In locations where these boxes are not likely to be disturbed, the tops shall be set flush with the adjoining ground. Boxes shall be adequately supported during backfilling to maintain vertical alignment.

F. Corporation Cocks

1. The tapping machine shall be rigidly fastened to the pipe as near the horizontal diameter as possible. The length of travel of the tap should be so established that when the stop is inserted and tightened with at 14" wrench, not more than one to three threads will be exposed on the outside. When a wet tapping machine is used, the corporation stop shall be inserted and tightened in accordance with the manufacturer's specifications.

3.5 INSTALLATION OF HYDRANTS

A. Hydrants and hydrant branches shall be tested at 175 psi and chlorinated as specified in this specification.

B. Hydrants shall be installed in conformance to AWWA C 600, Section 11, latest revision, using thrust blocks and restrained joints in accordance with the details shown on the Contract Drawings.

C. Hydrants, as detailed on the Contract Drawings, shall be set at the locations designated by the Engineer and shall be bedded on a firm foundation. A drainage pit 2-feet 6-inches in diameter and to the limits shown on the Contract Drawings shall be filled with crushed stone and satisfactorily compacted. During backfilling, additional crushed stone shall be brought up around, and 6-inch over the drain port. Each hydrant shall be set in true vertical alignment and shall be properly braced. Thrust blocks shall be placed between the back of the hydrant inlet and undisturbed soil at the end of the trench. Hydrant shall be set upon a slab of concrete not less than 4-in thick and 15-in square.

D. Hydrants shall be set plumb with the steamer nozzle facing the roadway and the center of the operating nut located 18-inches back from the face of curb or edge of pavement.

E. Hydrants shall be set such that the bottom of the breakaway feature shall be a minimum of 2-inches and a maximum of 4-inches above finish grade.

F. Once installed, hydrants shall be painted once again by the Contractor. Hydrants shall be painted in accordance with the Owner's requirements.

G. All iron work to be set below ground, after being thoroughly cleaned, shall be painted with two coats of asphalt varnish as specified in AWWA C502, latest revision and iron work to be left above ground shall be shop painted with two coats of paint.

H. Thrust Blocks: Concrete thrust blocks shall be placed between the back of the hydrant inlet and undisturbed soil at the end of the trench. Minimum bearing area shall be as shown on the Contract Drawings. Felt paper shall be placed as shown on the Contract Drawings. Care must be taken to ensure that concrete does not plug the drain ports.

3.6 BACKFILLING

A. General: Conduct excavation and backfill operations for utility installations in accordance with Section 312000 – EARTH MOVING, local requirements, and the contract documents.

B. Initial backfill shall be placed evenly on both sides of the pipe to distribute the load and not to cause movement or deflection of the pipe.

3.7 FIELD QUALITY CONTROL

A. Testing of Water Main/Service:

1. Prior to pressure testing, the entire line shall be water jetted to remove any rocks or debris that may have inadvertently entered the pipe during construction.
2. The Contractor in accordance with AWWA C651-99 specifications or latest revision will make pressure and leakage tests thereof, to determine that the ductile iron pipe is structurally safe and free of excess leakage. Pipeline shall be subject to a hydrostatic test of 150 pounds per square inch (psi) or 150% of the static pressure, whichever is greater. The Contractor shall furnish all equipment, materials, and labor for testing. Testing shall be done between valved off sections in approximately 1000-foot maximum section of the main. The Contractor shall furnish at his own expense the water needed for all water main testing.
3. Once the pipeline section has been filled at normal pressure and all entrapped air removed from the line, the Contractor shall raise the pressure to the approved test pressure by a special pressure pump taking water from a small tank of proper dimensions for satisfactorily measuring the rate of pumpage into the pipeline. The pipe shall maintain this pressure, within 5 psi, for a minimum of two hours during which time the line shall be checked for leaks. The measured water leakage shall not exceed the maximum allowed leakage as determined by the following equation for the section under test:

$$L = SDP^{1/2} / (133,200)$$

Where:
L = Allowable leakage, gallons per hour
S = Length of pipe section tested, feet (1,000-foot maximum)
D = Nominal pipe diameter, inches.
P = Average test pressure (psi)

Should leakage exceed this rate, the Contractor shall immediately locate the leak or leaks and repair same at his expense. Pipe shall be flushed and chlorinated when leakage does not exceed above standard. Approval does not absolve the Contractor from his responsibility if leaks develop within the new main or water services (to curb box) later within the period of warranty.

B. Testing of Fire Protection Service:

1. Testing of fire protection services shall conform to the most current NFPA requirements.

C. Chlorinating and Flushing:

1. Prior to chlorination, the Contractor shall properly flush mains. In general, flushing shall be performed at a flow rate required to achieve a minimum velocity of 2.5-feet per second (approximately 900 GPM in a 12-inch diameter main and 400 GPM in 8-inch diameter main). Flushing shall be performed for a sufficient period of time to allow for a minimum of 3 volume changes of water in the main (approximately 20 minutes per 1,000-foot of 8-inch main at the above flow rate).
2. Chlorinating shall be accomplished by pumping a chlorine solution into the mains. Water shall be allowed to enter the new water mains until the mains are full of a solution containing 25-ppm available chlorine. The valves shall then be closed and the chlorinated water allowed to stay in the mains for 24 hours. At the end of this period, the chlorine residual shall be at least 10 mg/l. If it is less than 10 mg/l measured, Contractor shall flush and rechlorinate the mains at no cost to the Owner. All valves and

hydrants shall be operated to ensure their proper disinfection and shall be manipulated to prevent superchlorinated water from entering the existing distribution system. After this period, the Contractor shall flush the mains until clear, clean water is being discharged.

3. Chlorinating and flushing shall be done in accordance with AWWA C651-99 Specifications.
4. Twenty-four hours after the main has been flushed of chlorinated water, bacteriological samples shall be taken. Water samples shall be taken from corporation stops along the length of the water main. A minimum of two (2) samples shall be taken, per 3,000 foot of pipe or on each street, whichever is greater, each in duplicate, in sterile bottles and sent to a State approved private laboratory for analyses. The Contractor shall perform all necessary work including delivery of samples to a certified laboratory, and shall include the cost of sampling and analysis in his bid price. The results of the tests on these samples will determine the acceptance of the work and allow these new mains to be connected to the District's system. The failure of any sample to pass the laboratory tests shall require the Contractor to reflush and rechlorinate the mains and resample and test the water until acceptable results are obtained, all at no additional cost to the Owner.
5. The Contractor shall submit a Disinfection report detailing the following:
    a. Type and form of disinfectant used.
    b. Date and time of disinfectant injection start and time of completion.
    c. Test locations.
    d. Initial and 24-hour disinfectant residuals (quantity in treated water) in ppm for each outlet tested.
    e. Date and time of flushing start and completion.
    f. Disinfectant residual after flushing in ppm for each outlet tested.
6. The Contractor shall submit a Bacteriological Report detailing the following:
    a. Date issued, project name, and testing laboratory name, address, and telephone number.
    b. Time and date of water sample collection.
    c. Name of person collecting samples.
    d. Test locations.
    e. Initial and 24-hour disinfectant residuals in ppm for each outlet tested.
    f. Coliform bacteria test results for each outlet tested.
    g. Certification that water conforms, or fails to conform, to bacterial standards.
7. Contractor shall note that work under this Contract shall NOT be considered completed until satisfactory installation and testing of the water mains have been completed.

3.8 FINAL INSPECTION

A. Final inspection and acceptance of pipe, valves, appurtenances, and hydrants shall be made by the Owner's Representative and the utility owner having jurisdiction of the particular system. Prior to placing the systems in service, all components shall be inspected, with the Owner’s Representative present, to ensure that no debris or other contaminants are present. If necessary, the Contractor shall clean and flush piping.

B. The Contractor is responsible for coordinating and scheduling the inspection of the work by local jurisdictional authorities. No additional payment will be made for inspections and permits required in the performance of the work.

END OF SECTION 331000

SECTION 33 30 00
SANITARY SEWERAGE UTILITIES

PART 1-GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all SECTIONS within DIVISION 1 – GENERAL REQUIREMENTS, which are hereby made a part of this Section of Specifications.

1.2 DESCRIPTION OF WORK

A. Work Included: Provide labor, materials, and equipment necessary to construct the sanitary sewer system complete, including connection to existing structures and testing, as indicated on the Drawings and as specified.

B. Unless otherwise indicated on the Drawings, building sewer service lines shall be installed from a point 10 feet outside the building foundation walls to the point of disposal.

C. Related Work: The following items are not included in this Section and will be performed under the designated Sections:

1. Section 311000 – SITE CLEARING for site clearing, removal of trees, stumps and other vegetation, topsoil stripping, stockpiling, clearing and grubbing, and removal of site surface and utility improvements.
2. Section 312000 – EARTH MOVING for excavation, backfill, and compaction required for sanitary sewerage system piping and structures.
3. Section 221316 – SANITARY WASTE AND VENT PIPING for building sanitary drain and vent requirements.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

1. Product Data: Submit manufacturer's technical product data and installation instructions for sanitary sewer system materials and products.
2. Submit descriptive literature for piping, fittings, couplings, and appurtenances showing dimensions, pipe and joint materials, and other details for each class or type of pipe or product to be furnished for this contract. All pipe furnished under the contract shall be manufactured in accordance with these Specifications.
3. Shop Drawings: The precast concrete structure shop drawing submittals for the manholes, septic tanks, dosing chambers, tight tanks, grease traps, wet wells, and valve pits shall contain erections drawings showing connections, cast-in items, waterproofing details, lifting hooks, and productions drawings showing elevations, sections, and details indicating sizes and quantities of reinforcement.
4. Submit shop drawings for structure hatches and frames and covers.
5. The Contractor shall submit buoyancy calculations for sanitary sewerage structures assuming groundwater is one (1) foot below finish grade. If buoyancy is an issue the structure(s) shall be modified to prevent uplift. All buoyancy calculations and precast

concrete structure designs shall be prepared and stamped by a professional Civil Engineer licensed in the Commonwealth of Massachusetts.

6. Material Certificates: Provide copies of material certificates signed by material producer and Contractor, certifying that each material item complies with, or exceeds specified requirements.
7. Prior to the acceptance of the sanitary sewerage system, the Contractor shall submit to the Engineer, for review and approval, As-Built Drawings that indicate the true measurement and location, horizontal and vertical, of all new construction. As-Built drawings shall be stamped and signed by a Massachusetts Licensed Land Surveyor or Licensed Professional Engineer. The as-built plans shall also be submitted electronically as an AutoCAD drawing file (release 2010 or higher).
8. Prior to the acceptance of the sanitary sewerage system, the Contractor shall submit the results of the leakage tests, pipe deflection measurements, and the video inspection reports.

1.4 REFERENCE STANDARDS

A. The following standards are applicable to the work of this Section to the extent referenced herein:

1. ASTM: American Society for Testing and Materials.
2. ANSI: American National Standards Institute.
3. Reference is made herein to the Commonwealth of Massachusetts, Department of Transportation (MassDOT), formerly Massachusetts Highway Department (MHD) Standard Specifications for Highways and Bridges, latest edition, hereinafter referred to as the “Standard Specifications”. All references to method of measurement, basis of payment, and payment items in the “Standard Specifications” are hereby deleted. References made to particular sections or paragraphs in the “Standard Specifications” shall include all related articles mentioned therein.
4. MassDOT Construction Standards, latest edition with amendments, hereinafter referred to as the “Construction Standards”.
5. City of Worcester Department of Public Works Standard Specifications and Details, February 1, 2021 or latest edition.

1.5 EXAMINATION OF SITE AND DOCUMENTS

A. It is hereby understood that the Contractor has carefully examined the site and all conditions affecting work under this Section. No claim for additional costs will be allowed because of a lack of knowledge of existing conditions as indicated in the Contract Documents, or obvious from observation on the site.

B. Plans, surveys, measurements, and dimensions under which the work is to be performed are believed to be correct, but the Contractor shall have examined them for himself during the bidding period and formed his own conclusions as to the full requirements of the work involved.

1.6 QUALITY ASSURANCE

A. Environmental Compliance: Comply with applicable portions of local environmental agency regulations pertaining to sanitary sewerage systems.

B. Utility Compliance: Comply with the City of Worcester Department of Public Works regulations, standards, and guidelines pertaining to sanitary sewerage system installation and inspections.

C. Sanitary sewerage system installation shall be in conformance with the latest edition of TR-16, Guides for the Design of Wastewater Treatment Works.

D. Plumbing Code Compliance: Comply with the applicable portions of the latest editions of the Massachusetts Plumbing Code and National Standard Plumbing Code pertaining to the selection and installation of sanitary sewerage system materials and products.

E. Subsurface Disposal System Code Compliance: Comply with the applicable portions of the Commonwealth of Massachusetts State Environmental Code Title V, 310 CMR 15.00, latest revision and the local Board of Health Regulations pertaining to the installation of sanitary sewerage system materials and products.

F. Manufacturer's Qualifications: Firms regularly engaged in manufacturing of sanitary sewer system products of type, materials, and sizes required, whose products have been in satisfactory use in similar service for not less than five years.

G. Installer's Qualifications: Firms with at least three years of successful installation experience on projects with sanitary sewer work similar to that required for the project.

1.7 PROJECT CONDITIONS

A. Site Information: Perform site inspection and survey, research utility records, and verify existing utility locations and elevations. Verify that sewerage system structures and piping may be installed in compliance with Contract Drawings and referenced standards.

B. Interruption of Existing Sanitary Sewer Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to the requirements indicated:

1. Notify Architect no fewer than two days in advance of proposed interruption of service.
2. Do not proceed with interruption of service without Architect's written permission.

1.8 SEQUENCING AND SCHEDULING

A. Coordinate with interior building sanitary sewerage system piping.

B. Coordinate with other utility work.

C. The Contractor is responsible for developing a sequence of work to maintain existing services in operation until the new services are operational.

D. The Contractor is responsible for coordinating and scheduling the inspection of the work by the jurisdictional authority. All permits and inspection costs and fees shall be included in the bid prices and no additional costs will be paid to the Contractor.

PART 2-PRODUCTS

2.1 PRECAST CONCRETE VAULTS AND TANKS

A. The precast reinforced concrete vault and tank structures shall be designed by a Massachusetts Registered Professional Engineer employed by the Contractor, in accordance with the applicable sections of the following references.

1. Commonwealth of Massachusetts State Building Code, latest edition.
2. American Concrete Institute, ACI 318 “Building Code Requirements for Reinforced Concrete.”
3. AASHTO, “Standard Specification for Highway Bridges.”
4. Precast Concrete Institute, “Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products, MNL-116.

B. The structures shall be designed for the following loads and possible combinations thereof:

1. Lateral soil pressure=60 PCF (H), where H is the height from grade as shown on the Contract Drawings, to the point of the structure being considered.
2. Soil weight shall be assumed to be 120 PCF.
3. AASHTO HS-20-44 loading.
4. Weight of precast concrete structure.
5. Initial handling and erection loading, including design of galvanized lifting hooks using safety factor = 4.0.

C. Investigate buoyancy and soil bearing considerations assuming the groundwater elevation is one-foot below the ground surface.

D. Concrete shall have a minimum 28-day compressive strength of 5,000 psi using Type II or III Portland cement with 8% maximum content of tricalcium aluminate, ASTM C150. A “normal dosage” of air-entraining agent shall be added to the concrete during the mixing cycle. Reinforcement shall be deformed billet-steel ASTM A615 or 7-wire strand ASTM A416, Grade 270 (if prestressed).

E. Dimensions and opening sizes and locations shall be as indicated on the Contract Drawings.

F. Pipe Connections: Vault and tank structures shall have pipe openings to accept the type of pipe specified. Pipe opening shall be minimum size required to receive the pipe and shall be accurately set to conform to the required line and grade. Sewer pipe shall be joined to the wall of the concrete structure with flexible pipe sleeves as indicated on the drawings. Flexible pipe sleeves shall be cast in the walls of the structure during the manufacturing process. Flexible pipe sleeves shall be NPC Kor-N-Seal Pipe-to-Manhole Connector as manufactured by Trelleborg Pipe Seals Milford, Inc., Milford, NH; Z-Lok as manufactured by A-Lok Products, Inc., Tullytown, PA; Tylox CIB Series Cast-In Boot Connector as manufactured by Hamilton Kent, Winchester, TN; or approved equal.

G. Waterproofing: The exterior surfaces of precast structures shall be given two heavy coats of waterproofing concrete sealer. The material shall be Aqua-Safe Concrete Sealer as manufactured by Bay Oil Company, Chicopee, MA; Bitumastic 300M as manufactured by Carboline Company, St. Louis, MO; Sonoshield HLM 5000 as manufactured by BASF Corporation Building Systems, Shakopee, MN; ConSeal CS-1800 as manufactured by Concrete Sealants, Inc., Tipp City, OH; or acceptable equivalent products. The waterproofing material shall be applied by brush or spray and in accordance with the

instructions of the manufacturer. Time shall be allowed between coats to permit sufficient drying so that the application of the second coat has no effect on the first coat.

H. Brick Masonry: Bricks shall be sound, hard, uniformly burned, regular, and uniform in shape and size. Underburned or salmon brick shall not be acceptable. Only whole brick shall be used.

1. Bricks for raising manhole and catch basin frames to finished grade shall conform to ASTM C32, Grade MS.
2. Mortar shall be in conformance with ASTM C270, Type M. The mortar shall be composed of one-part Portland cement, 3-1/2 parts sand, and ¼ parts hydrated lime, by volume. Portland cement shall be ASTM C150, Type II; hydrated lime shall be Type S conforming to ASTM D207.
3. Sand shall be washed, cleaned, screened, well-graded with all particles passing a No. 4 sieve, and conform to ASTM C33.

2.2 PRECAST CONCRETE MANHOLES

A. General: Provide precast reinforced concrete structures as indicated and complying with ASTM C 478.

B. Manhole Top: Precast concrete of concentric cone, eccentric cone, or flat slab top type, as necessary for the installation as indicated in the Contract Drawings. Tops shall be designed to meet H20 loadings.

C. Base and Riser Sections: Precast concrete, with base riser section with integral floor. Diameter, base and riser thicknesses shall be as indicated on the Contract Drawings.

D. Cement: Type II.

E. Concrete strength: 4,000 psi minimum.

F. Precast concrete sections shall have tongue and groove joints.

G. Horizontal Joints: Joints between sections of concrete structures shall be sealed with a flexible, watertight joint, made with preformed butyl rubber joint sealant conforming to ASTM C990 or with a rubber gasket joint conforming to ASTM C443. Sealants and/or gaskets shall be installed in accordance with the manufacturer’s written instructions.

H. Manhole Steps: Steps for manholes shall be non-skid raised edge-front steel reinforced polypropylene plastic type with at least 13-inch-wide stepping surface. Steps shall meet the requirements of ASTM C-478 and AASHTO M-199. Steel shall be 1/2-inch grade 60 conforming to ASTM A615 encapsulated with molded copolymer polypropylene. The polypropylene shall conform to ASTM D-4101. Rungs shall protrude no more than 6 inches from the wall. The portion of the legs to be embedded in the precast section shall have fins and be tapered to ensure a secure bond. Steps shall start a foot above the shelf of the manhole floor and continued twelve inches on center spacing up through the completed height of the unit. The steps shall finish no lower than twenty-four (24)-inches below the rim elevation. Placement into precast walls shall be by a method recommended by the supplier of the precast manhole sections. Steps shall be installed per the manufacturer’s specifications.

I. Pipe Connections: Sewer manhole shall have pipe openings to accept the type of pipe specified. Pipe opening shall be minimum size require to receive the pipe and shall be accurately set to conform to the required line and grade. Sewer pipe shall be joined to the wall of the concrete manhole with flexible manhole sleeves as indicated on the drawings. Flexible manhole sleeves shall be cast in the walls of the manholes during the manufacturing process. Flexible manhole sleeves shall be NPC Kor-N-Seal Pipe-to-Manhole Connector as manufactured by Trelleborg Pipe Seals Milford, Inc., Milford, NH; Z-Lok as manufactured by A-Lok Products, Inc., Tullytown, PA; Tylox CIB Series Cast-In Boot Connector as manufactured by Hamilton Kent, Winchester, TN; or approved equal.

J. Waterproofing: The exterior surfaces of precast structures shall be given two heavy coats of waterproofing concrete sealer. The material shall be Aqua-Safe Concrete Sealer as manufactured by Bay Oil Company, Chicopee, MA; Bitumastic 300M as manufactured by Carboline Company, St. Louis, MO; Sonoshield HLM 5000 as manufactured by BASF Corporation Building Systems, Shakopee, MN; ConSeal CS-1800 as manufactured by Concrete Sealants, Inc., Tipp City, OH; or acceptable equivalent products. The waterproofing material shall be applied by brush or spray and in accordance with the instructions of the manufacturer. Time shall be allowed between coats to permit sufficient drying so that the application of the second coat has no effect on the first coat.

K. Sanitary Sewer Brick Masonry: Bricks shall be sound, hard, uniformly burned, regular, and uniform in shape and size. Underburned or salmon brick shall not be acceptable. Only whole brick shall be used.

1. Bricks for channels and shelves shall conform to ASTM C32, Grade SS except that the mean of five tests for absorptions shall not exceed 8 percent and no individual brick exceed 11 percent.
2. Brick for raising manhole frames to finished grade shall conform to ASTM C32, Grade MS.
3. Mortar shall be in conformance with ASTM C270, Type M. The mortar shall be composed of one-part Portland cement, 3-1/2 parts sand, and ¼ parts hydrated lime, by volume. Portland cement shall be ASTM C150, Type II; hydrated lime shall be Type S conforming to ASTM D207.
4. Sand shall be washed, cleaned, screened, well-graded with all particles passing a No. 4 sieve, and conform to ASTM C33.

L. In sewer manholes, the invert channel within the structure shall be an inverted arch with bricks laid as stretchers and on edge and so constructed as to conform in shape to the lower half of the pipe. The shelf in manholes shall consist of bricks laid flat and the top of the shelf shall be at the elevation of the top of the pipe, as indicated on the Contract Drawings, and shall be sloped to flow toward the channel.

M. Inverts in sewer manholes shall conform accurately to size of the adjoining pipe. Side inverts and main inverts where the direction changes shall be laid out in smooth curves of the longest possible radius which is tangent, within the manhole, to the centerline of the adjoining pipe lines.

N. Sewer manholes shall be constructed with drop connections when the proposed invert of the connection is at least 2 feet above the manhole invert. All drop connections will be of the external type. The drop pipe shall be constructed of SDR 35 PVC sewer pipe. The drop piping and horizontal cleanout sections will be sized the same as the sewer main piping and shall enter the manhole at the invert elevation of the main. The drop portion of the piping

shall be secured with anchor straps. The drop piping shall be encased with control density fill.

O. For all manhole depths greater than 10 feet, the inside diameter of the manholes shall be at least 5'-0".

P. Safety landings shall be installed inside manholes greater than 16-feet in depth.

Q. When installing manholes on existing lines and when flows cannot be diverted, drop-over manholes shall be used. Drop-over manholes shall be precast with openings cast in the sidewalls of sufficient size to fit over the existing line(s) to remain in service. Drop-over manholes shall be set on a precast or cast-in-place concrete base slab. Drop-over manholes shall be manufactured to the same requirements and dimensions as standard manholes.

2.3 CONCRETE BLOCK MANHOLES – NOT USED

2.4 MANHOLE FRAMES AND COVERS

A. Manhole frame and cover shall be EJIW 1056Z frame and EJIW 1056A cover or LeBaron LC239/L23C-1. Non-bolted casting manhole covers shall be supplied with a closed pickhole and shall show the wording 'Worcester, A Town June 14, 1722: A City February 29, 1848" cast into said cover.

2.5 PVC PIPE

A. General: Provide pipes of the following materials of class indicated. Provide pipe fittings and accessories of same materials and class as pipes with joining method, as indicated. The piping shall be manufactured by an established manufacturer of good reputation in the industry and in a permanent plant adapted to meet all the design requirements of the pipe.

B. PVC Sewer Pipe

1. PVC (Polyvinyl Chloride) Gravity Sewer Pipe and Fittings: ASTM D3034, SDR 35, for elastomeric gasket joints. Pipe 18 to 36 inches in diameter shall conform to ASTM F679, T-1 heavy wall. The pipe shall have a SDR ration of 35 and a pipe stiffness of 46 psi.

2. Joints: PVC pipe shall have an integral wall bell and spigot push-on joint with elastomeric gaskets secured in place in the bell of the pipe. The bell shall consist of an integral wall section with solid cross section elastomeric gasket, factory assembled, securely locked in place to prevent displacement during assembly. Pipe joints shall conform to ASTM D3212 and elastomeric gaskets shall conform to ASTM F477.

3. Spigot pipe ends shall be supplied with bevels from the manufacturer to ensure proper insertion. Each spigot end shall have an "assembly stripe" imprinted thereon to which the bell end of the mated pipe will extend upon proper joining of the two pipes.

4. PVC gravity sewer fittings and accessories shall be as manufactured and furnished by the pipe supplier or approved equal and have bell and spigot configurations compatible with that of the pipe.

C. PVC Sewer Force Main Pipe – NOT USED

D. PVC Conduit

1. PVC Schedule 40: Provide PVC Pipe, Schedule 40, where shown on the Contract Drawings. Pipe shall comply with ASTM D1785 and be manufactured from virgin PVC

plastic conforming to ASTM D1784. Pipe shall be Underwriter's Laboratories listed for use in underground installations.

2. Joints and solvent cements shall conform to ASTM 2564.

2.6 DUCTILE IRON PIPE AND FITTINGS

A. General: Provide pipes of the following materials of class indicated. Provide pipe fittings and accessories of same materials and class as pipes with joining method, as indicated. The piping shall be manufactured by an established manufacturer of good reputation in the industry and in a permanent plant adapted to meet all the design requirements of the pipe.

1. Ductile iron pipe shall be that of a manufacturer who can demonstrate at least five years of successful experience in manufacturing ductile iron pipe. The pipe shall be equipped with push on type, restrained joint, or mechanical joints, as required.
2. All ductile iron drain pipe shall conform to American Water Works Association (AWWA) C150 and AWWA C151.
3. The ductile iron pipe shall be Class 52 and furnished in minimum nominal 18-foot lengths, with Push-on or Mechanical Joints as manufactured by U.S. Pipe and Foundry Company, Atlantic States Cast Iron Pipe Co., Clow Corporation, or approved equal with gaskets conforming to AWWA C111 "Rubber Gasket Joints".
4. The ductile iron sewer pipe shall be PROTECTO 401 Ceramic Epoxy lined and the pipe exterior asphalt seal coated in accordance with AWWA C104.
5. The pipe shall be furnished along with necessary materials and equipment recommended by the manufacturer for use in joining pipe lengths and fittings.
6. Fittings shall be short body ductile iron Class 350 Mechanical Joint, conforming to ANSI Specification AWWA C153, latest edition, for pipe sizes 16 inches and smaller, and Class 350 standard Mechanical Joint fittings conforming to AWWA C110, latest edition, for pipe sizes 16 through 24 inches, unless specifically stated otherwise in the Specifications or on the Contract Drawings. Fittings shall have the same lining and coating as the pipe specified above. All fittings shall be marked with the weight and shall have distinctly cast upon them the pressure rating, the manufacturer's identification, nominal diameter of openings and the number of degrees or fraction of the circle on all bends. Fittings greater than 24 inches shall be as specified above except they shall be Class 250. All accessories (gland, gaskets, T-bolts, and nuts) shall be in accordance with AWWA C111. All mechanical joint bolts (T-bolts) shall be Cor-Ten or equal.
7. Contractor shall provide all adapters and fittings such as transition couplings, as determined in the field, necessary to complete all cross connections, whether or not specifically stated in the Contract Drawings and Specifications.
8. All pipes shall be marked with the class, thickness designation, and initials of the manufacturer.
9. If required the manufacturer shall supply the Engineer with certificates of compliance with these Specifications and certification that each piece of ductile iron pipe has been tested at the foundry with the Ball Impression Test, Ring Bending, or equal.
10. Pipe for use with sleeve-type couplings shall be as specified except that the ends shall be plain (without bells or beads). The ends shall be cast or machined at right angles to the axis.

B. INSPECTION, TESTS, AND ACCEPTANCE FOR DUCTILE IRON PIPE

1. All pipe delivered to the job site shall be accompanied by test reports certifying that the pipe and fittings conform to "AWWA Standard for Ductile Iron Pipe, for Water and Other Liquids" (AWWA H3) and (AWWA C151).
2. All tests shall be made in accordance with the methods prescribed by the above mentioned AWWA Standards, and the acceptance or rejection shall be based on the test results.
3. Pipe which does not conform to the requirements of this contract shall be immediately removed and replaced by the Contractor.
4. All ductile iron pipe to be installed under this Contract may be inspected at the foundry for compliance with these Specifications by an independent testing laboratory selected by the Owner. The Contractor shall require the manufacturer's cooperation in these inspections. The cost of foundry inspection of all pipe approved for this Contract, plus the cost of the inspection of a reasonable amount of disapproved pipe, will be borne by the Owner.

C. SLEEVE COUPLINGS FOR DUCTILE IRON PIPE

1. Sleeve couplings and accessories shall be pressure rated at least equal to that of the pipe. Couplings shall be cast iron and shall be Dresser Style 53 or 153, Rockwell Style 441, Baker Series 4245 or acceptable equivalent product. The couplings shall be provided with Cor-Ten bolts and nuts or approved equal.
2. After assembly, all exterior surfaces including the bolts and nuts shall be thoroughly coated with two coats of heavy-duty protective coating. The interior of the coupling shall be epoxy coated. Coating shall be a minimum of 10 mils. and a maximum of 20 mils. dry film thickness thermosetting epoxy.

2.7 CLEANOUTS

A. General: Provide cast-iron ferrule and countersunk brass cleanout plug, with round cast-iron access frame and heavy-duty, secured, scoriated cast-iron cover.

B. The sewer cleanouts shall be minimum 6-inch diameter or sized to match the service pipe, whichever is greater. The cleanout shall be complete with a flush mount over. The cleanout cover shall be clearly marked “SEWER” and shall be minimum eight inches in diameter or two inches greater than the cleanout size, whichever is greater. Cleanouts shall include a watertight cap.

2.8 SEWER COUPLINGS

A. Sewer Couplings shall be pressure rated at least equal to that of the pipe. The coupling sleeve shall be 1/4-inch minimum thickness elastomeric polyvinylchloride with a minimum tensile strength of 1500 psi. The sleeve shall fit snugly onto the pipe to be joined and be resistant to common chemicals present in sewerage. Adjustable pipe clamps shall consist of a slotted band that mate with the worm gear screw and a screw housing all manufactured of stainless steel, and suitable for underground service.

2.9 SANITARY SEWER PUMP STATION – NOT USED

2.10 IDENTIFICATION

A. Detectable Underground Warning Tapes: Acid and alkali-resistant, polyethylene plastic film warming tape, 6-inches wide by 4-mils. minimum thickness, with continuously printed caption

in black letters “CAUTION – xxxxx LINE BURIED BELOW.” The text and color of the tape shall be as shown in the table below. The tape shall have a metallic core encased in a protective jacket for corrosion protection and be detectable by a metal detector when the tape is buried up to 2.5 feet deep.

Color	Utility
Safety Red	Electric
High Visibility Safety Yellow	Gas, Oil, Steam
Safety Alert Orange	Telephone, Communications, Cable Television
Safety Precaution Blue	Water System, Irrigation
Safety Green	Sanitary Sewer, Storm Sewer

PART 3-EXECUTION

3.1 GENERAL INSTALLATION

A. General Locations and Arrangements: Contract Drawings indicate the general location and arrangement of the underground sanitary sewer system piping. Location and arrangement of piping layout take into account many design considerations. Install the piping as indicated, to the extent practical. Any modifications to the layout of the sewer system shall be submitted to the Engineer for review and approval at least five days prior to the start of the affected work.

B. Install piping beginning at low point of systems, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings in accordance with manufacturer's recommendations, accepted practices, and utility owner’s requirements. Maintain swab or drag in line and pull past each joint as it is completed.

C. All piping shall be laid in the dry. Adequate measures shall be taken to prevent floatation of pipe in the trench.

D. Whenever encountered within the trench, existing abandoned water, sewer, and/or drain lines shall be removed within the trench limits, unless otherwise noted. The remaining portion of the abandoned lines shall be plugged at all open ends.

E. When bell and spigot pipes are used, bell holes shall be dug in the bedding to accommodate the bells. They shall be deep enough to ensure that the bell does not bear on the bottom of the hole but shall be excessively wide in the longitudinal direction of the installation.

F. Use manholes for changes in direction, except where a fitting is indicated. Use fittings for branch connections, except where direct tap into existing sewer is indicated.

G. Use proper size increasers, reducers, and couplings, where different size or material of pipes and fittings are connected. Reduction of the size of piping in the direction of flow is prohibited without the written approval of the Engineer.

H. Install piping pitched down in direction of flow as indicated on the Contract Drawings.

I. Extend sanitary sewerage system piping to connect to building sanitary drains, of sizes and in locations indicated on the Contract Drawings.

J. Install piping in accordance with governing authorities having jurisdiction, except where more stringent requirements are indicated.

K. Acceptance of Pipe: Acceptance will be on the basis of tests specified herein before. The quality of all materials used in the pipe, the process of manufacture, and the finished pipe shall be subject to review by the Engineer. Inspection may be made at the place of manufacture, or on the work site after delivery or at both places and the pipe shall be subject to rejection at any time on account of failure to meet any of the specification requirements, even though sample pipe units may have been accepted as satisfactory at the place of manufacture. All pipe which is rejected shall be immediately removed from the project site by the Contractor.

L. Pipe Storage: Pipe sections shall not be stored on areas over the newly laid pipe or other pipelines which might be damaged by the superimposed load, and storage sections shall be restricted to approved areas.

M. Handling Pipe: Each pipe unit shall be handled into its position in the trench only in such manner and by such means, as the Engineer accepts as satisfactory. The Contractor will be required to furnish suitable devices to permit satisfactory support of all parts of the pipe unit when it is lifted.

N. Laying Pipe: Except where a concrete cradle or envelope is required, the pipe shall be laid in a crushed stone cradle. In trenches, no blocking or supporting of the piping by concrete, stones, bricks, wooden wedges, or method other than bedding the pipe on crushed stone will be permitted. Each length of pipe shall be shoved home against the pipe previously laid and held securely in position. Joints shall not be "pulled" or "cramped" without approval of the Engineer.

O. Jointing Pipe: After the pipe are aligned in the trench and are ready to be jointed, all joint surfaces shall be cleaned.

P. Alignment and Placement: All pipe shall be laid with extreme care as to grade and alignment. Each pipe shall be so laid as to form a close joint with the next adjoining pipe and bring the inverts continuously to the required grade.

1. Stakeout of drain work and setting of line and grade is the responsibility of the Contractor.
2. The Contractor shall establish centerline and offset stakes at each manhole, plus one intermediate centerline and offset stake as a check point between manholes. Laser aligning shall not be used to establish a continuous line in excess of 400-feet.

Q. Cleaning: Care shall be taken to prevent earth, water, and other materials from entering the pipeline. As soon as possible after the pipe and manholes are completed, the Contractor shall clean out the pipeline and manholes being careful to prevent soil, water, and debris from entering any existing sewer system.

1. Place plugs in end of uncompleted conduit at end of day or whenever work stops.
2. Flush lines between manholes to remove collected debris.

R. Review of Completed Sanitary Sewer System: The completed sewer system shall be visually inspected by the Owner’s Representative. If the visual observation of the completed sewer or any part thereof shows any pipe, manhole, or joint to be of defective work or material, the defect shall be replaced or repaired as directed by the Engineer or the Owner’s Representative. The Contractor shall coordinate and provide site access for inspection. All

repairs or replacement of deficient or incomplete work shall be performed by the Contractor at no cost to the Owner.

3.2 INSTALLATION OF SEWER MANHOLES

A. The bases shall be supported on a compacted level foundation of gravel borrow a minimum of 12 inches thick. Crushed stone may be substituted for gravel borrow if field conditions at the bottom of the excavation are wet.

B. The Contractor shall install the manholes as soon as the pipe laying reaches the location of the manhole.

C. The Contractor shall accurately locate each manhole and set accurate templates to conform to the required line and grade. Any manhole which is not installed in the correct location or oriented improperly shall be removed and rebuilt in its proper location, alignment, and orientation at no additional cost to the Owner.

D. Manhole risers and tops shall be installed using approved butyl rubber sealant or rubber gasket for sealing joints of manhole risers and tops; jointing shall be performed in accordance with the manufacturer's recommendations. Manhole risers and tops shall be installed level and plumb. Water shall not be permitted to rise over newly made joints, nor until after inspection as to their acceptability. All jointing shall be done in a manner to ensure watertight joints.

E. Openings shall be provided in the precast concrete manhole risers to receive entering pipes and these openings shall be made at the place of manufacture. Connection of sanitary pipes to manholes shall be made by means of a flexible rubber sleeve/boot cast integral with the structure sidewall.

F. Care shall be taken to ensure the openings are made to permit setting of the entering pipe at its correct elevation as indicated or directed. Manhole risers and tops shall be installed so the manhole steps shall be in alignment.

G. All holes used for handling shall be thoroughly plugged with non-shrink grout.

H. Cutting or tampering in the field, for purpose of creating new sidewall openings or altering existing openings, will not be permitted without approval of the Engineer.

I. All interior manhole joints where the sealing material is not flush with the inside wall shall be grouted with non-shrink mortar and finished by hand/wet-brush.

J. Clean all debris, mortar, and soil from the bottom of all structures prior to final acceptance of the project.

3.3 INSTALLATION OF PRECAST CONCRETE TANKS AND VAULTS

A. The bases shall be supported on a compacted level foundation of gravel borrow a minimum of 12 inches thick. Crushed stone may be substituted for gravel borrow if field conditions at the bottom of the excavation are wet.

B. The precast base shall be placed level at the specified grade. The entire base should be in contact with the underlying compacted granular material. Subsequent sections, complete with joint seals, shall be installed in accordance with the precast concrete manufacturer’s recommendations. Structure sections shall be installed level and plumb. Water shall not be

permitted to rise over newly made joints, nor until after inspection as to their acceptability. All jointing shall be done in a manner to ensure watertight joints.

C. Adjustment of the structure can be performed by lifting the upper sections free of the excavated area, re-leveling the base, and re-installing the sections. Damaged sections and gaskets shall be repaired or replaced as necessary. Once the structure has been constructed, any lift holes shall be plugged watertight with mortar or non-shrink grout. Any precast structure which is not installed in the correct location or oriented improperly shall be removed and rebuilt in its proper location, alignment, and orientation at no additional cost to the Owner.

D. Inlet and outlet pipes should be securely set into the structure using approved pipe seals (flexible boot connections, where applicable) so that the structure is watertight. Care shall be taken to ensure that the openings are made to permit setting of the entering pipe at its correct elevation as indicated or directed. Cutting or tampering in the field, for purpose of creating new sidewall openings or altering existing openings, will not be permitted.

E. Grade rings shall be installed to set the frame and cover at the required elevation. The grade rings shall be laid in a full bed of mortar with successive units being joined using sealant recommended by the manufacturer. Frames for the cover shall be set in a full bed of mortar at the elevation specified.

F. Clean all debris, mortar, and soil from the bottom of all structures prior to final acceptance of the project.

3.4 STRUCTURE REBUILT

A. When in the opinion of the Engineer or Owner's Representative, an existing masonry structure walls show deterioration, the structure shall be rebuilt. The casting and deteriorated masonry shall be removed in a careful and neat manner until only a sound condition remains. Concrete blocks shall be used to rebuild the structure. The new masonry construction, replacing of the casting, and other incidental work shall be performed as specified above.

1. The Contractor's base bid shall include rebuilding [ ] vertical linear feet of existing manhole structures.

3.5 SETTING MANHOLE FRAMES AND COVERS

A. Manhole frames shall be set with tops conforming accurately to the grade of the pavement or finished ground surface as indicated on the Contract Drawings or as directed.

B. Brick shall be used to bring the frame and cover to the required elevation.

1. Frames shall be set concentric with the opening in the top of the manhole on two to four courses of brick in a full bed of mortar. A thick ring of mortar extending to the outer edge of brick or concrete shall be placed all around the bottom flange of the cast iron frame. The mortar shall be smoothly finished to a height of 5 inches above the flange for 8-inch frames and sloped to shed water away from the frame.
2. Completed brick installation shall be coated with mortar at least a ¾ inch thick on the outside to provide a fully sealed and watertight collar between the top manhole section and the cover frame.
3. Only clean bricks shall be used in brick work to adjust frame elevations. The brick shall be moistened by suitable means.

C. The castings of structures located within the pavement area shall not be completely set to the established grade until the bottom course of pavement has been laid. The final setting of all other casting shall be performed at the proper stage of construction.

D. Manhole covers shall be left in place in the frame until completion of other work at the manholes.

3.6 PVC PIPE

A. General: Install piping in accordance with governing authorities having jurisdiction, except where more stringent requirements are indicated.

B. PIPE HANDLING

1. All pipe and fittings shall be carefully handled from the truck onto the ground and into the trench or excavation so as to prevent damage to the pipe. Pipes shall be kept free of dirt and foreign material especially on the inside. Joint ends of pipe shall especially be kept clean.
2. Pipe stored on site shall be protected from direct sun light and suitably ventilated.
3. Pipe or fittings shall not be dropped. All pipe or fittings shall be examined before laying, and no piece shall be installed which is found to be defective.

C. ALIGNMENT AND PLACEMENT OF PVC PIPE

1. Bedding material for the pipe must be installed with care in the area around the pipe. Bedding material must be placed to provide uniform and adequate support under pipe. Do not use blocking to bring pipe up to grade.
2. Provide bell holes at each joint to permit joint to be assembled properly while maintaining uniform pipe support.
3. Place and consolidate the bedding material under the pipe haunch to provide adequate side support while avoiding both vertical and lateral displacement of pipe.
4. Initial backfill must be completed to a point at least 12-inches over the top of the pipe and be hand placed. Use little or no tamping of initial backfill directly over the top of pipe. Compaction methods may be utilized during final backfilling.
5. No length of pipe shall be laid until the proceeding lengths of pipe have been thoroughly embedded in place, to prevent movement or disturbance of the pipe alignment.
6. Full lengths of pipe shall be used in the installation except that partial lengths may be used at the entrance to structures, and to accommodate the required locations of service connection fittings.
7. Pipe entrances to structures shall be cut flush with the inside face of the structure, and cut ends of the pipe surface within the structure shall be properly rounded and finished so that there will be no protrusion, ragged edges or imperfections that will impede or affect the hydraulic characteristics of the sewage flow. The method of cutting and finishing shall be subject to the approval of the Engineer.
8. The Contractor shall protect the installation at all times during construction. The movement of construction equipment, vehicles and loads over and adjacent to any pipe shall be performed at the Contractor’s own risk.
9. Sewer pipes shall be laid to the required grades by use of a laser and target system, unless otherwise specifically approved by the Engineer.
10. Separation Between Sewer Lines and Water Lines:

a. A minimum horizontal separation of ten (10) feet shall be maintained between proposed sewer lines and existing water lines. The distance shall be measured edge to edge. In cases where it is not practical to maintain a ten foot separation, it is permitted to install a sewer line closer to a water line, provided that the sewer line is laid in a separate trench or on an undisturbed earth shelf located eighteen (18) inches above the top of sewer. In either case, the elevation of the top of the sewer shall be at least 18 inches below the bottom of the water line.

b. Whenever sewers must cross under water lines, the sewer shall be laid at such an elevation that the top of the sewer is at least 18 inches below the bottom of the water line. When the elevation of the sewer cannot be varied to provide the 18 inches of vertical clearance, the water line shall be relocated to provide this separation or reconstructed with mechanical –joint pipe for a distance of 10 feet on each side of the sewer. One full length of water pipe shall be centered over the sewer so that both joints will be as far from the sewer as possible.

c. When it is impossible to obtain horizontal and/or vertical separation as indicated above, both the water line and sewer line shall be constructed of mechanical joint ductile iron pipe for a distance of ten (10) feet to either side of the respective centerline. The water line shall be cement lined and the sewer line shall be provided with ceramic epoxy lining for sewer applications. Both pipes shall be pressure tested by an approved method to assure water-tightness or both pipes shall be encased in control density fill. One (1) full length of water pipe shall be centered over the sewer at the crossing.

11. Jointing of PVC sewer pipe and fittings shall be done in accordance with the printed recommendations of the manufacturer and as specified. The bell end of the pipe shall be thoroughly cleaned. The joint surfaces and the gasket shall be lubricated prior to making up the joint. The position of the gasket shall be checked to ensure the joint has been properly made and is watertight. Care shall be taken not to exceed the manufacturer's recommended maximum deflection allowed for each joint.

12. PVC pipe shall be pushed home by hand or with the use of bar and block. The use of power equipment, such as a backhoe bucket, is not acceptable.

13. Field-cut pipe ends shall be cut square and the pipe surface beveled to the size and shape of a factory-finished beveled end. All sharp edges shall be rounded off.

14. Detectable warning tape shall also be installed 2-feet below the existing ground surfaces for later use in locating the pipe's exact position.

3.7 PLACEMENT OF DUCTILE IRON PIPE AND FITTINGS

A. Care shall be taken in loading, transportation, and unloading to prevent injury to the pipe or coatings. Pipe or fittings shall not be dropped. All pipe and fittings shall be examined before placement, and no piece shall be installed which is found to be defective. Any damage to the pipe coatings shall be repaired as directed by the Engineer.

B. If any defective pipe is discovered after it has been placed, it shall be removed and replaced with a sound pipe in a satisfactory manner by the Contractor, at his own expense. All pipe and fittings shall be kept clean until they are used in the work, be thoroughly cleaned before placement, and when placed, shall conform to the lines and grades required. Ductile iron pipe and fittings shall be installed in accordance with requirements of AWWA Standard Specification C600 except as otherwise provided herein. A firm even bearing throughout the length of the pipe shall be constructed by compacting gravel borrow around the pipe and up to the springline.

1. Blocking will not be permitted.

C. All pipes shall be sound and clean before placement. When pipe laying is not in progress, including lunchtime, the open ends of the pipe shall be temporarily closed by watertight plug or other acceptable means. Alignment shall be maintained during placement. The deflection at joints shall not exceed sixty percent of that recommended by the manufacturer. Fittings, in addition to those shown on the plans, shall be provided, if required, in crossing utilities, which may be encountered upon opening the trench. Solid sleeves shall be used only where allowed by the Engineer.

D. When cutting pipe is required, the cutting shall be done by machine, leaving a smooth cut at right angles to the axis of the pipe. Cut ends of pipe to be used with a push-on type bell shall be beveled to conform to the manufactured spigot end.

E. The Contractor shall take care not to damage pipe by impact, bending, compression, or abrasion during handling, and installation. Joint ends of pipe especially shall be kept clean.

F. Pipe shall be stored above ground at a height no greater than 5 feet and with even support for the pipe barrel.

G. Only nylon protected slings shall be used for handling the pipe. No hooks, chains or bare cables will be permitted.

H. Gaskets shall be shipped in cartons and stored in a clean area, away from grease, oil, heat, direct sunlight and ozone producing electric motors.

I. Jointing of ductile iron push on pipe and fittings shall be done in accordance with the printed recommendations of the manufacturer and as specified. The last 8 inches of the outside of the spigot end of pipe and the inside of the bell end of pipe shall be thoroughly cleaned. The joint surfaces and the gasket shall be painted with a lubricant just prior to making up the joint. The spigot end shall then be gently pushed home into the bell. The position of the gasket shall be checked to ensure that the joint has been properly made and is watertight. Care shall be taken not to exceed the manufacturer's recommended maximum deflection allowed for each joint.

1. Jointing Ductile Iron Pipe (Push-On Type): Push-on joints shall be made in strict accordance with the manufacturer's instructions. Pipe shall be laid with bell ends looking ahead. A rubber gasket shall be inserted in the groove of the bell end of the pipe, and the joint surfaces cleaned and lubricated. The plain end of the pipe to be entered shall then be inserted in alignment with the bell of the pipe to which it is to be joined, and pushed home with a jack or by other means. After joining the pipe, a metal feeler shall be used to make certain that the rubber gasket is correctly located.
2. Jointing Mechanical Joint Fittings: Mechanical joints at valves, fittings, and where designated shall be installed in accordance with the "Notes on Method of Installation" under ANSI Specification A 21.11 and the instructions of the manufacturer. To assemble the joints in the field, the Contractor shall thoroughly clean the joint surfaces and rubber gasket with soapy water before tightening the bolts. Bolts shall be tight to the specified torque. Under no condition shall extension wrenches or pipes over handles or ordinary ratchet wrenches be used to secure greater leverage.

J. Installation and jointing of ductile iron pipe shall be in accordance with AWWA C600, Sections 9b and 9c, latest revision, as applicable.

K. Ductile iron pipe installed within 5-feet of gas lines shall be fully encased with polyethylene material. Polyethylene shall be 8 millimeters thick and comply with AWWA C 105.

3.8 CLEANOUTS

A. Install cleanouts and extensions from sewer pipe to grade as indicated on the Contract Drawings. Set cleanout frame and cover in concrete 18 by 18 by 6-inches deep, except where location is in bituminous or concrete paving. Set top of cleanout 1-inch above surrounding earth grade or flush with grade when installed in paving.

3.9 SEWER COUPLINGS

A. Couplings which are factory manufactured shall be installed at all connections from existing pipe to proposed pipe unless the existing pipe is the same material as the proposed pipe and the bell and spigot end of the pipes to be connected are compatible and free from defects. All sewer couplings shall be installed in accordance with the manufacturer's recommendations for the types of pipe to be connected.

3.10 TAP CONNECTIONS

A. Make connections to existing piping and underground structures so that finished work will conform as nearly as practicable to the requirements specified for new work. The contractor shall verify the location, size, invert, and type of existing pipes at all points of connection prior to make the connections.

B. Make branch connections from side into existing piping by installing a wye or T-wyes, and couplings manufactured for use with the same type of pipe as indicated on the Contract Drawings. The Contractor shall install a 45° wye branch or 90° tee fittings in the sewer pipe at all locations where building sewer service pipe connections are shown on the Drawings. Connections of the sewer service pipes shall be made into the wye branches or tees by means of 45° bends. The connections shall be made thoroughly watertight and concrete shall be placed under each connection to bear on undisturbed earth and firmly support the connection.

C. Protect existing piping and structures to prevent concrete or debris from entering while making tap connections. Remove debris, concrete, or other extraneous material that may accumulate.

D. Connections into existing sewer facilities shall be performed in accordance with the requirements of the City of Worcester. The Contractor shall comply with all such requirements, including securing of all required permits and paying the costs thereof.

3.11 INSTALLATION OF PUMP SYSTEM – NOT USED

3.12 INSTALLATION OF IDENTIFICATION

A. Install continuous plastic underground warning tape during back-filling of trench for underground sanitary sewerage system piping. Locate tape two-feet below finished grade, directly over piping.

3.13 BACKFILLING

A. General: Conduct excavation and backfill operations for structure and pipe installations in accordance with Section 312000 – EARTH MOVING, local requirements, and the contract documents.

B. Initial backfill shall be placed evenly on both sides of the pipe to distribute the load and not to cause movement or deflection of the pipe.

3.14 FIELD QUALITY CONTROL

A. Testing: Perform testing of completed piping in accordance with City of Worcester DPW requirements and the following:

1. Testing shall be witnessed by the Owner's Representative and the local authority.
2. The test shall be by vacuum or by water exfiltration as described herein:
3. Vacuum Testing of Precast Concrete Manholes
   a. The vacuum test shall be conducted on each manhole in accordance with ASTM C1244. Test results will be judged by the length of time it takes for the applied vacuum to drop from 10 inches of mercury to 9 inches. If the time is less than that listed in Table 1 of ASTM C1244, the manhole will have failed the test. Test times from Table 1 are excerpted below.

TABLE 1

Minimum Test Times for Various Manhole Diameters

	Diameter (Inches)		
Depth (Feet)	48	60	72
	Times (Seconds)		
0-12	30	39	49
12-16	40	52	67
16-20	50	65	81
20-24	59	78	97
26-30	74	98	121

   b. If the manhole fails the initial test, the Contractor shall locate the leaks and make the proper repairs. Leaks may be filled with a wet slurry of accepted quick setting material. If the manhole should again fail the vacuum test, additional repairs shall be made, and the manhole water tested as specified below.
4. Water Exfiltration Testing of Precast Concrete Manholes
   a. After the manhole has been assembled in place, all lifting holes shall be filled and pointed with an approved non-shrinking mortar. All pipes and other openings into the manhole shall be suitably plugged and the plugs braced to prevent flow out. The test shall be made prior to placing the shelf and invert. If the groundwater table has been allowed to rise above the bottom of the manhole, it shall be lowered for the duration of the test.
   b. The manhole shall be filled with water to the top of the cone section. If the excavation has not been backfilled and observation indicates no visible leakage, that is, no water visibly moving down the surface of the manhole, the manhole may be considered to be satisfactorily water tight. If the test, as described above, is unsatisfactory as determined by the Owner's Representative and/or the City of Worcester's Inspector or if the manhole excavation has been backfilled, the test shall be continued. A period of time may be permitted if the Contractor so wishes, to allow for absorption by the manhole. At the end of this period, the manhole shall be refilled to the top of the cone, if necessary, and a measuring time of at least 8 hours begun. At the end of the test period, the manhole shall be refilled to the top

of the cone, measuring the volume of water added. This amount shall be extrapolated to a 24-hour loss rate and the leakage determined on the basis of depth. The leakage for each manhole shall not exceed one gallon per vertical foot for a 24-hour period. If the manhole fails this requirement, but the leakage does not exceed 3 gallons per vertical foot per day, repairs by approved methods may be made as required by the Owner's Representative and/or City of Worcester's Inspector to bring the leakage within the allowable rate of one gallon per foot per day. Leakage due to a defective section or joint or exceeding the 3 gallons per vertical foot per day shall be cause for rejection of the manhole. It shall be the Contractor's responsibility to uncover the rejected manhole as necessary and to disassemble, reconstruct or replace it as required by the Owner's Representative. The manhole shall then be retested and, if satisfactory, interior joints shall be filled and pointed.

c. No adjustment in the leakage allowance will be made for unknown causes such as leaking plugs, absorption, etc. It shall be assumed that all loss of water during the test is a result of leaks through joints or through the concrete. Furthermore, the Contractor shall take any steps necessary to assure the Owner's Representative and/or City of Worcester's Inspector that the water table is below the bottom of the manhole throughout the test.

d. If the groundwater table is above the highest joint in the manhole, and there is no leakage into the manhole, as determined by the Owner's Representative and/or the City of Worcester's Inspector, such a test can serve to evaluate water-tightness of the manhole. However, if the Owner's Representative and/or the City of Worcester's Inspector is not satisfied with the results, the Contractor shall lower the water table and carry out the test as described hereinbefore.

5. Leakage Testing of Gravity Sewer Piping and Fittings

a. On completion of a section of sewer, including building connections, the Contractor shall install suitable bulkheads as required, dewater and test the sewer for leakage.

b. Unless otherwise approved, the section shall be tested using low-pressure air test procedures. If circumstances permit, the Owner's Representative and/or the City of Worcester's Inspector may allow testing by infiltration or exfiltration in lieu of air testing.

c. The air test procedures shall conform to the Uni-Bell Recommended Practice for Low-Pressure Air Testing of Installed Sewer Pipe, UNI-B-6. The starting air pressure for the test shall be 4 psig (greater than the average groundwater back pressure of any groundwater above the pipe, but not greater than 9.0 psig). The minimum duration permitted for the prescribed low-pressure air exfiltration pressure drop between two consecutive manholes shall not be less than provided in Table I or Table II of UNI-B-6. Note that UNI-B-6 suggests that use of the 0.5 psig pressure drop is more efficient since the time requirements are half of the 1.0 psig-pressure drop.

d. Using the air pressure test, if there has been no leakage (zero psig drop) after one hour of testing, the section undergoing test shall have passed.

e. If either infiltration or exfiltration testing is permitted by the Engineer, the test shall be conducted for at least 24 hours. The amount of infiltration or exfiltration shall not exceed 100 gallons per inch diameter per mile of sewer per 24 hours.

f. The infiltration test measures leakage into a section of sewer and may be used only where the groundwater level is one foot or more above the crown of the section of sewer pipe at its upper end and at least one foot above the top of building connections and chimneys. For making the infiltration tests, underdrains, if used,

shall be plugged and other groundwater drainage shall be stopped to permit the groundwater to return to its normal level insofar as practicable. Allowances shall be made for water that may enter the sewer through pipe connections and inlets during the infiltration test.

g. Where the groundwater level is less than 1 foot above the top of the pipe at its upper end, the exfiltration test may be used. The sewers shall be subjected to an internal pressure by plugging the pipe at the lower end and then filling the pipelines and manholes with clean water to a height of 2 feet above the highest point in the system to be tested, including main pipeline, service connections, and chimneys. When slopes between manholes are steep, the Contractor shall ensure that this test can be accomplished without danger of forcing stoppers from wye or tee branches.

h. The rate of exfiltration from the sewers shall be determined by measuring the amount of water required to maintain the water level at the elevation established at the beginning of the test

i. The Contractor shall construct such weirs or other means of measurements as may be required, shall furnish water, and shall do all necessary pumping to enable the test to be properly made.

j. The Contractor shall be responsible for the satisfactory water-tightness of the entire section of sewer. Should the sections under test fail to meet the requirements, the Contractor shall do all work of locating and repairing leaks and retesting as the Engineer may require without additional compensation. A plan of the method of repairing any leaks that are found shall be submitted to the Engineer for review.

6. Pressure sewers (force mains) – NOT USED

7. Pipe Deflection Measurement

a. In accordance with ASTM D3034, no less than 30 days after completion of the PVC sewer pipe installation, the Contractor shall test the pipeline for deflection using a "go/no go" deflection mandrel having a minimum of nine evenly spaced arms or prongs. The "go/no go" gauge shall be hand pulled through all sections of the pipeline by the Contractor. The Contractor shall submit drawings of the "go/no go" gauge to the Owner's Representative and/or the City of Worcester's Inspector for approval prior to testing. Complete dimensions of the gauge for each diameter of pipe to be tested shall be in accordance with ASTM D3034.

b. Any section of pipe found to exceed 7.5 percent deflection shall be deemed a failed pipe and shall be excavated and replaced by the Contractor at his own expense.

8. Video Inspections: Seven days after the completion of the backfilling of each section of new pipe, as defined as a length of pipe between two manholes, the Contractor shall provide a televised inspection of the pipe to be submitted to the Designer. The Owner's Representative shall be present during the recording. The recording shall be in DVD color format with audio and shall show a clear picture of the inside of the new pipe. If the Designer determines that the DVD is unacceptable for review the contractor shall re-televise the line until an acceptable DVD has been submitted. In the event that the pipe is not acceptable for any reason relating to the proper construction of the pipe according to these specifications, the Contractor will be responsible to re-excavate and repair the defects to the satisfaction of the Designer at no additional cost.

B. Cleaning: Clear interior of piping and structures of dirt and other superfluous material as work progresses. Maintain swab or drag in piping and pull past each joint as it is completed.

1. In large, accessible piping, brushes and brooms may be used for cleaning.

2. Place watertight plugs in ends of uncompleted pipe at end of day or whenever work stops. If water is in the trench when work is resumed, the plug shall not be removed until the trench has been dewatered and all danger of water entering the pipe eliminated.
3. Flush piping between manholes to remove collected debris.

C. Interior Inspection: Inspect piping to determine whether line displacement or other damage has occurred.

1. Make inspections after pipe between manholes has been installed and approximately 2 feet of backfill is in place, and again at completion of project.
2. If inspection indicates poor alignment, debris, displaced pipe, infiltration or other defects, the Contractor shall correct such defects and reinspect.

D. Prior to acceptance of the sanitary sewerage system, the Contractor shall submit the following to the Architect and to the local authority:

1. System As-Built Plan stamped by a Professional Land Surveyor or Engineer Registered in the Commonwealth of Massachusetts.
2. Video inspection DVDs and report: The report shall document the observations of the video inspections.
3. Deflection test report: The report shall fully describe the test procedures and list the test results. The report shall be signed by the Contractor’s superintendent.
4. Leakage test report: The report shall fully describe the test procedures and list the test results. The report shall be signed by the Contractor’s superintendent.

3.15 FINAL INSPECTION

A. Final inspection and acceptance of the sanitary sewer system shall be made by the Owner's Representative and the utility owner having jurisdiction of the particular system.

B. Prior to placing the systems in service, all components shall be inspected, with the Owner’s Representative present, to ensure that no debris or other contaminants are present. If necessary, the Contractor shall clean the structures and flush piping.

C. The Contractor is responsible for coordinating and scheduling the inspection of the work by local jurisdictional authorities. No additional payment will be made for inspections and permits required in the performance of the work.

End of Section

SECTION 334000
STORM DRAINAGE UTILITIES

PART 1 – GENERAL

1.1 GENERAL PROVISIONS

A. Attention is directed to the CONTRACT AND GENERAL CONDITIONS and all SECTIONS within DIVISION 1 – GENERAL REQUIREMENTS, which are hereby made a part of this section of Specifications.

1.2 DESCRIPTION OF WORK

A. Work Included: Provide labor, materials, and equipment necessary to construct the storm drainage system complete including but not limited to surface drain, retaining walls drain, and footing and foundation drain systems; and including connections to existing structures and testing, as indicated on the Drawings and as specified.

B. Unless otherwise indicated on the Drawings, building drain service lines shall be installed from a point 10 feet outside the building foundation walls to the point of disposal.

C. Related Work: The following items are noted and included in this Section and will be performed under the designated sections:

1. Section 312000 – EARTH MOVING for excavation, backfill, & compaction requirements.
2. Section 221400 – FACILITY STORM DRAINAGE for building storm drainage piping.

1.3 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

1. Product Data: Submit manufacturer's technical product data and installation instructions for storm drain system materials and products.
2. Submit descriptive literature for piping, fittings, couplings, and appurtenances showing pipe dimensions, pipe and joint materials and dimensions, and other details for each class or type of pipe or product to be furnished for this contract. All pipe furnished under the contract shall be manufactured in accordance with these Specifications.
3. Submit shop drawings for storm drain systems, showing piping and manhole materials and sizes.
4. Submit shop drawings of complete layout of detention/retention structures, including all fittings and appurtenances.
5. The precast concrete structure shop drawing submittals for the manholes, catch basins, gas trap, grease trap, other vaults, and tanks shall contain erection drawings showing connections, cast-in items, waterproofing details, lifting hooks, and production drawings showing elevations, sections, and details indicating sizes and quantities of reinforcement.
6. Submit shop drawings for structure frames, grates, and covers.
7. Submit shop drawings for footing drains and underdrain systems at the building and utility coordination process/drawings as specified in division 1 specifications.
8. Filter fabric: Submit the manufacturer's information.

9. For trench drains submit shop drawings showing a schematic plan of the entire trench drain system, listing all parts being provided with exact centerline dimensions suitable for installation. Copies of the manufacturer's recommended method of installation and assembly shall be submitted for review.
10. For water quality structures and stormwater quality filter treatment structures submit shop drawings for the structure and performance. Shop drawings shall detail the structures precast concrete components, inserts, and castings. Where an external bypass is required, the manufacturer shall provide calculations and designs for all structures, piping and any other required material applicable to the proper functioning of the system, stamped by a Professional Engineer.
11. The Contractor shall submit buoyancy calculations for storm drainage structures assuming groundwater is one (1) foot below finish grade. If buoyancy is an issue the structure(s) shall be modified to prevent uplift. All buoyancy calculations and precast concrete structure designs shall be prepared and sealed by a professional Civil Engineer licensed in the state of Massachusetts.
12. Prior to the acceptance of the storm drainage system, the Contractor shall submit to the Engineer, for review and approval, As-Built Drawings that indicate the true measurement and location, horizontal and vertical, of all new construction. As-Built drawings shall be stamped and signed by a Massachusetts Licensed Land Surveyor or Licensed Professional Engineer. The as-built plans shall also be submitted electronically as an AutoCAD drawing file (release 2010 or higher).
13. Prior to acceptance of the storm drainage system, the Contractor shall submit the results of the pipe deflection measurements and the video inspection reports.

1.4 REFERENCE STANDARDS

A. The following standards are applicable to the work of this Section to the extent referenced herein:

1. ASTM: American Society for Testing and Materials.
2. ANSI: American National Standards Institute.
3. AASHTO: American Association of State Highway and Transportation Officials.
4. Reference is made herein to the Commonwealth of Massachusetts, Department of Transportation (MassDOT), Formerly Massachusetts Highway Department (MHD) Standard Specifications for Highways and Bridges, latest edition, hereinafter referred to as the "Standard Specifications". All references to method of measurement, basis of payment, and payment items in the "Standard Specifications" are hereby deleted. References made to particular sections or paragraphs in the "Standard Specifications" shall include all related articles mentioned therein.
5. MassDOT Construction Standards, latest Edition with amendments, hereinafter referred to as the "Construction Standards."
6. City of Worcester Department of Public Works Standard Specifications and Details, February 1, 2021 or latest edition.

1.5 EXAMINATION OF SITE AND DOCUMENTS

A. It is hereby understood that the Contractor has carefully examined the site and all conditions affecting work under this Section. No claim for additional costs will be allowed because of a lack of knowledge of existing conditions as indicated in the Contract Documents, or obvious from observation of the site.

B. Plans, surveys, measurements, and dimensions under which the work is to be performed are believed to be correct, but the Contractor shall have examined them for himself during the bidding period and formed his own conclusions as to the full requirements of the work involved.

1.6 QUALITY ASSURANCE

A. Environmental Compliance: Comply with applicable portions of local environmental agency regulations pertaining to storm drain systems.

B. Utility Compliance: Comply with the City of Worcester Department of Public Works regulations, standards, and guidelines pertaining to storm drainage system installation and inspections.

C. Plumbing Code Compliance: Comply with applicable portions of Massachusetts Plumbing Code and National Standard Plumbing Code, latest editions, pertaining to selection and installation of storm drain system's materials and products.

D. Manufacturer's Qualifications: Firms regularly engaged in manufacturing of storm drain system's products of types, materials, and sizes required, whose products have been in satisfactory use in similar service for not less than five years.

E. Installer's Qualifications: Firms with at least three years of successful installation experience on projects with storm drain work similar to that required for the project.

1.7 PROJECT CONDITIONS

A. Site Information: Perform site inspection and survey, research utility records, and verify existing utility locations and elevations. Verify that storm drainage system structures and piping may be installed in compliance with Contract Drawings and referenced standards.

B. Interruption of Existing Storm Drainage System: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to the requirements indicated:

1. Notify Architect no fewer than two days in advance of proposed interruption of service.
2. Do not proceed with interruption of service without Architect’s written permission.

1.8 SEQUENCING AND SCHEDULING

A. Coordinate with interior building storm drain system piping.

B. Coordinate with other utility work.

C. The Contractor is responsible for developing a sequence of work to maintain existing services in operation until the new services are operational.

D. The Contractor is responsible for coordinating and scheduling the inspection of the work by the jurisdictional authority. All permits and inspection costs and fees shall be included in the bid prices and no additional costs will be paid to the Contractor.

PART 2 – PRODUCTS

2.1 PRECAST CONCRETE VAULTS AND TANKS

A. The precast reinforced concrete vault and tank structures shall be designed by a Massachusetts Registered Professional Engineer employed by the Contractor, in accordance with the applicable sections of the following references:

1. Commonwealth of Massachusetts State Building Code, latest edition.
2. American Concrete Institute, ACI 318 "Building Code Requirements for Reinforced Concrete."
3. AASHTO, "Standard Specifications for Highway Bridges."
4. Precast Concrete Institute, "Manual for Quality Control for Plants and Production of Precast and Prestressed Concrete Products, MNL-116."

B. The structures shall be designed for the following loads and possible combinations thereof:

1. Lateral soil pressure = 60 PCF (H), where H is the height from grade, as shown on the Contract Drawings, to the point of the structure being considered.
2. Soil weight shall be assumed to be 120 PCF.
3. AASHTO HS-20-44 loading.
4. Weight of precast concrete structure.
5. Initial handling and erection loadings, including design of galvanized lifting hooks using a safety factor = 4.0.

C. Investigate buoyancy and soil bearing considerations assuming the groundwater elevation is one-foot below the ground surface.

D. Concrete shall have a minimum 28-day compressive strength of 5,000 psi using Type II or III Portland cement with 8% maximum content of tricalcium aluminate, ASTM C150. A "normal dosage" of air-entraining agent shall be added to the concrete during the mixing cycle. Reinforcement shall be deformed billet-steel ASTM A615 or 7-wire strand ASTM A416, Grade 270 (if prestressed).

E. Dimensions and opening sizes and locations shall be as indicated on the Contract Drawings.

F. Pipe Connections: Vault and tank structures shall have pipe openings to accept the type of pipe specified. Pipe opening shall be minimum size required to receive the pipe and shall be accurately set to conform to the required line and grade. Sewer pipe shall be joined to the wall of the concrete structure with flexible pipe sleeves as indicated on the drawings. Flexible pipe sleeves shall be cast in the walls of the structure during the manufacturing process. Flexible pipe sleeves shall be NPC Kor-N-Seal Pipe-to-Manhole Connector as manufactured by Trelleborg Pipe Seals Milford, Inc., Milford, NH; Z-Lok as manufactured by A-Lok Products, Inc., Tullytown, PA; Tylox CIB Series Cast-In Boot Connector as manufactured by Hamilton Kent, Winchester, TN; or approved equal.

G. Waterproofing: The exterior surfaces of precast structures shall be given two heavy coats of waterproofing concrete sealer. The material shall be Aqua-Safe Concrete Sealer as manufactured by Bay Oil Company, Chicopee, MA; Bitumastic 300M as manufactured by Carboline Company, St. Louis, MO; Sonoshield HLM 5000 as manufactured by BASF Corporation Building Systems, Shakopee, MN; ConSeal CS-1800 as manufactured by Concrete Sealants, Inc., Tipp City, OH; or acceptable equivalent products. The waterproofing material shall be applied by brush or spray and in accordance with the

instructions of the manufacturer. Time shall be allowed between coats to permit sufficient drying so that the application of the second coat has no effect on the first coat.

H. Storm Drainage Brick Masonry: Bricks shall be sound, hard, uniformly burned, regular, and uniform in shape and size. Underburned or salmon brick shall not be acceptable. Only whole brick shall be used.

1. Bricks for raising manhole and catch basin frames to finished grade shall conform to ASTM C32, Grade MS.
2. Mortar shall be in conformance with ASTM C270, Type M. The mortar shall be composed of one-part Portland cement, 3-1/2 parts sand, and ¼ parts hydrated lime, by volume. Portland cement shall be ASTM C150, Type II; hydrated lime shall be Type S conforming to ASTM D207.
3. Sand shall be washed, cleaned, screened, well-graded with all particles passing a No. 4 sieve, and conform to ASTM C33.

2.2 MANHOLES AND CATCH BASINS

A. General: Provide precast reinforced concrete structures as indicated and complying with ASTM C 478.

B. Manhole Top: Precast concrete, of concentric cone, eccentric cone, or flat slab top type, as indicated in the Contract Drawings. Tops shall be designed to meet H20 loadings.

C. Base and Riser Sections: Precast concrete, with base riser section with integral floor. Diameter, base and riser thicknesses shall be as indicated on the Contract Drawings.

D. Cement: Type II.

E. Concrete strength: 4,000 psi minimum.

F. Precast concrete sections shall have tongue and groove joints.

G. Horizontal Joints: Joints between sections of concrete structures shall be sealed with a flexible, watertight joint, made with preformed butyl rubber joint sealant conforming to ASTM C990 or with a rubber gasket joint conforming to ASTM C443. Sealants and/or gaskets shall be installed in accordance with the manufacturer’s written instructions.

H. Manhole Steps: Steps for manholes shall be non-skid raised edge-front steel reinforced polypropylene plastic type with at least 13-inch-wide stepping surface. Steps shall meet the requirements of ASTM C-478 and AASHTO M-199. Steel shall be 1/2-inch grade 60 conforming to ASTM A615 encapsulated with molded copolymer polypropylene. The polypropylene shall conform to ASTM D-4101. Rungs shall protrude no more than 6 inches from the wall. The portion of the legs to be embedded in the precast section shall have fins and be tapered to ensure a secure bond. Steps shall start a foot above the shelf of the manhole floor and continued twelve inches on center spacing up through the completed height of the unit. The steps shall finish no lower than twenty-four (24)-inches below the rim elevation. Placement into precast walls shall be by a method recommended by the supplier of the precast manhole sections. Steps shall be installed per the manufacturer’s specifications.

I. Pipe Connections: Drainage structures shall have plain beveled openings to accept the type of pipe specified. Pipe openings shall be minimum size required to receive the pipe and shall be accurately set to conform to the required line and grade. Drain pipe shall be joined to the wall of the concrete manhole or catch basin with non-shrink grout or flexible manhole

sleeve as indicated on the drawings. Grout mixture shall follow instructions provided by manufacturer. Flexible manhole sleeves shall be cast in the walls of the manholes during the manufacturing process. Flexible manhole sleeves shall be NPC Kor-N-Seal Pipe-to-Manhole Connector as manufactured by Trelleborg Pipe Seals Milford, Inc., Milford, NH; Z-Lok as manufactured by A-Lok Products, Inc., Tullytown, PA; Tylox CIB Series Cast-In Boot Connector as manufactured by Hamilton Kent, Winchester, TN; or approved equal.

J. Drain manholes shall be constructed with drop connections when the proposed invert of the connection is at least 2.75 feet above the manhole invert. All drop manholes will be of the external type. The drop pipe shall be constructed of minimum SDR 35 PVC. The drop piping and horizontal cleanout sections will be sized the same as the drain main piping and shall enter the manhole at invert elevation. The drop portion of the piping shall be secured with anchor straps. The drop piping shall be encased with control density fill.

K. Storm Drainage Brick Masonry: Bricks shall be sound, hard, uniformly burned, regular, and uniform in shape and size. Underburned or salmon brick shall not be acceptable. Only whole brick shall be used.

1. Bricks for raising manhole and catch basin frames to finished grade shall conform to ASTM C32, Grade MS.
2. Mortar shall be in conformance with ASTM C270, Type M. The mortar shall be composed of one-part Portland cement, 3-1/2 parts sand, and ¼ parts hydrated lime, by volume. Portland cement shall be ASTM C150, Type II; hydrated lime shall be Type S conforming to ASTM D207.
3. Sand shall be washed, cleaned, screened, well-graded with all particles passing a No. 4 sieve, and conform to ASTM C33.

L. Inverts in drain manholes shall be constructed of cement concrete shaped to conform accurately to size of the adjoining pipe. Side inverts and main inverts where the direction changes shall be laid out in smooth curves of the longest possible radius which is tangent, within the manhole, to the centerline of the adjoining pipe lines.

M. For all manhole depths greater than 10 feet, the inside diameter of the manholes shall be at least 5’-0”.

N. Safety landings will be installed inside manholes greater than 16-feet in depth.

O. When installing manholes on existing lines and when flows cannot be diverted, drop-over manholes shall be used. Drop-over manholes shall be precast with opening cast in the sidewalls of sufficient size to fit over the existing line(s) to remain in service. Drop-over manholes shall be set on a precast or cast-in-place concrete base slab. Drop-over manholes shall be manufactured to the same requirements and dimensions as standard manholes.

2.3 CONCRETE BLOCK MANHOLES – NOT USED

2.4 MANHOLE FRAMES AND COVERS

A. Manhole frame and cover shall be EJIW 1056Z frame and EJIW 1056A cover or LeBaron LC239/L23C-1. Non-bolted casting manhole covers shall be supplied with a closed pickhole and shall show the wording ‘Worcester, A Town June 14, 1722: A City February 29, 1848” cast into said cover.

2.5 CATCH BASIN FRAMES AND GRATES

A. Catch Basin grate shall be EJIW 7288M or LeBaron L28SG1. Catch basin inlet frame shall be EJIW 7288Z (4-Flange), EJIW 7288Z1 (3-Flange) or LeBaron LF288, Type E.

2.6 CATCH BASIN HOODS

A. All catch basin hoods shall be City of Worcester standard 8-inch green traps as supplied by Tolman Manufacturing Company of Boston, MA, or approved equal. Outlet pipes from catch basin hoods shall be 8-inch DR18, Class 150 PVC pipe.

2.7 AREA DRAIN

A. Area drains required for this contract shall be manufactured from PVC pipe stock, utilizing a thermo-molding process to reform the pipe stock to the specified configuration. The drainage pipe connection stubs shall be manufactured from PVC pipe stock and formed to provide a watertight connection with the specified pipe system. This joint tightness shall conform to ASTM D3212 for joints for drain and sewer plastic pipe using flexible elastomeric seals conforming to ASTM F477. The pipe bell spigot shall be joined to the main body of the area drain. A PVC cap shall be installed at the bottom of the area drain sump. The raw material used to manufacture the pipe stock that is used to manufacture the main body and pipe stubs of the surface drainage inlets shall conform to ASTM D1784 cell class 12454. Area drains shall be manufactured by Nyloplast or approved equal.

B. Grates and frames furnished for all area drainage shall be ductile iron for sizes 8”, 10”, 12”, 15”, 18” and 24” and shall be made specifically for each basin so as to provide a round bottom flange that closely matches the diameter of the surface drainage inlet. Grates for area drains shall be capable of supporting H-20-wheel loading for vehicular traffic areas or H-10 loading for pedestrian traffic areas unless otherwise noted. 12” and 15” square grates shall be hinged to the frame using pins. Metal used in the manufacture of the castings shall conform to ASTM A536 grade 70-50-05 for ductile iron. Grates shall be provided painted black. Grates in walkways shall meet ADA requirements. Grates in planting beds shall be domed grates. The grates furnished for area drains bioretention areas shall be 24” in diameter. All area drain grates should include a locking device. Area drain grates shall be manufactured by Nyloplast or approved equal.

2.8 INLINE DRAINS

A. The inline drain required for this contract shall be manufactured from PVC pipe stock, utilizing a thermos-molding process to reform the pipe stock to the furnished configuration. The drainage pipe connection stubs shall be manufactured from PVC pipe stock and formed to provide a watertight connection with the specified pipe system. This joint tightness shall conform to ASTM D3212 for joints for drain and sewer plastic pipe using flexible elastomeric seals. The flexible elastomeric seals shall conform to ASTM F477. The pipe bell spigot shall be joined to the inline drain body by use of a swage mechanical joint. The ram material used to manufacture the pipe stock that is used to manufacture the inline drain body and pipe stubs of the surface drainage inlets shall conform to ASTM D1784 cell class 12454.

B. The grates furnished for all surface drainage inlets shall be ductile iron grates for sizes 8”, 10”, 12”,15”, 18”, and 30” shall be made specifically for each fitting so as to provide a round bottom flange that closely matches the diameter of the surface drainage inlet. Grates for inline drains shall be capable of supporting H-20-wheel loading for traffic areas or H-10 loading for pedestrian areas. 12” and 15” square grates will be hinged to the frame using pins. Metal used in the manufacture of the castings shall conform to ASTM A536 grade 70-50-05 for ductile iron. Grates shall be provided painted black.

2.9 MANUFACTURED TRENCH DRAINS

A. Trench drains shall be a pre-engineered, manufactured system that conforms to the design loading requirements of AASHTO H-20 and HS-20 (minimum) with the following minimum requirements:

1. Channels shall be manufactured from polyester resin polymer concrete with an integrally cast-in ductile iron edge rail. Each edge rail shall be at least ¼" thick.
2. The polymer concrete shall be frost proof, dilute acid and alkali resistant, and salt proof (B117 Salt Spray Test Compliant) with the minimum properties as follows:
   a. Compressive Strength: 14,000 psi
   b. Flexural Strength: 4,000 psi
   c. Tensile Strength: 1,500 psi
   d. Water Absorption: 0.07%
3. The system shall be 12" nominal internal width with a 14.2" overall width and a built-in slope of 0.5%. Channel invert shall have a partial radius in the trench bottom. All channels shall be interlocking with a male/female joint.
4. Trench drain grates shall be slotted ductile iron conforming to ASTM 536-84, Grade 65-45-12. After removal of grates, there shall be uninterrupted access to the trench to aid maintenance.
5. Units shall have horizontal cast in anchoring keys on the outside wall to ensure maximum mechanical bond to the surrounding bedding material and pavement surface.
6. The trench drain shall have a locking device that directly connects the grate to the frame.
7. Channel shall be designed to withstand loading to Load Class F as outlined by EN 1433. Grate type shall be appropriate to meet the system load class specified.
8. Trench drain system shall be installed in strict accordance with manufacturer's installation instructions, recommendations, and shop drawings.

2.10 WATER QUALITY STRUCTURE

A. The water quality drainage structure models indicated on the Contract Drawings are Stormceptor® as manufactured by the Stormceptor Corporation, Rockville, MD. Equivalent structures include Vortechs as manufactured by Vortechnics, Inc. of Portland, ME, and Downstream Defender as manufactured by Hydro International of Portland, ME. Other acceptable equivalent manufactured devices may be used if following requirements are met. Prior to acceptance, the contractor shall receive written approval for use of said substitution from the City of Worcester and/or their authorized representatives.

B. The water quality structure shall have a proven laboratory test record of having the capability to remove a minimum of 80% of the sediment load from the low-flow storm conditions from the total catchment area of the drainage system. Laboratory testing methods shall conform to the "Technology Acceptance Reciprocity Partnership" (TARP) Tier II protocol or other acceptable equivalent method and shall have the capability of removing clay and silt size particles.

C. The available water quality structure laboratory performance documentation shall achieve a grade of "2" or better as rated through the "Massachusetts Stormwater Evaluation Project" (MAStep).

D. The water quality structure shall be installed underground as part of the stormwater system.

E. The structure shall be constructed of precast concrete components.

F. Precast Concrete Sections: All precast concrete components shall be designed and manufactured to a minimum live load of AASHTO HS-20 truck loading.

G. Horizontal Joints: Joints between sections of concrete structures shall be sealed with a flexible, watertight joint, made with preformed butyl rubber joint sealant conforming to ASTM C990 or with a rubber gasket joint conforming to ASTM C443. Sealants and/or gaskets shall be installed in accordance with the manufacturer's written instructions.

H. Frame and Cover: The frame and cover shall clearly indicate with lettering the unit's name cast into the cover to allow for easy identification in the field.

I. Concrete: Precast concrete components shall meet the requirements of ASTM C478.

J. Fiberglass: The fiberglass portion of the water treatment structure shall be constructed in accordance with ASTM D409, Contact Molded Glass Fiber Reinforced Chemical Resistant Tanks. The internal fiberglass insert shall be bolted and sealed watertight inside the reinforced concrete component.

K. The water quality structure shall be vertically oriented with easy access to facilitate maintenance.

L. The first 16 inches of oil storage should be lined with fiberglass or other coating acceptable to the Engineer to provide double-wall containment of any hydrocarbon-based material.

M. Water quality structure shall be equipped with high flow bypass that shall be physically separated from the separation area to prevent mixing.

N. The structure shall be maintainable from the surface via access points without requiring entry into the structure.

O. The structure shall be designed to prevent the formation of secondary eddy currents or scour conditions.

P. The structure shall be able to be installed to the invert elevations of the drainage system as detailed on the Contract Drawings.

Q. The water quality structure shall be capable of containing floatable substances such as oil and gasoline within the structure during normal operation as well as periods of service and repair. Floatables containment shall be achieved without the use of floatable additives.

R. The water quality structure shall not be compromised by backwater conditions i.e., trapped pollutants should not be resuspended and scoured from the interceptor during backwater conditions.

S. Calculations stamped by a Professional Engineer shall be supplied to demonstrate that the water quality structures will accept the design flow rates without causing a backwater condition.

T. Inspection: All precast concrete sections shall be inspected to ensure that dimensions, appearance, and quality of the product meet the requirements of ASTM C478.

2.11 STORMWATER QUALITY FILTER TREATMENT STRUCTURE – NOT USED

2.12 DUCTILE IRON PIPE AND FITTINGS

A. General: Provide pipes of the following materials of class indicated. Provide pipe fittings and accessories of same materials and class as pipes with joining method, as indicated. The piping shall be manufactured by an established manufacturer of good reputation in the industry and in a permanent plant adapted to meet all the design requirements of the pipe.

1. Ductile iron pipe shall be that of a manufacturer who can demonstrate at least five years of successful experience in manufacturing ductile iron pipe. The pipe shall be equipped with push on type, restrained joint, or mechanical joints, as required.
2. All ductile iron drain pipe shall conform to American Water Works Association (AWWA) C150 and AWWA C151.
3. The ductile iron pipe shall be Class 52 and furnished in minimum nominal 18-foot lengths, with Push-on as manufactured by U.S. Pipe and Foundry Company, Atlantic States Cast Iron Pipe Co., Clow Corporation, or approved equal with gaskets conforming to AWWA C111 "Rubber Gasket Joints".
4. Ductile iron drain pipe shall be cement-mortar lined and the pipe exterior asphalt seal coated in accordance with AWWA C104.
5. The pipe shall be furnished along with necessary materials and equipment recommended by the manufacturer for use in joining pipe lengths and fittings.
6. Fittings shall be ASTM A-536 ductile iron with mechanical joint fittings. All fittings 3 inch through 48 inches in diameter shall meet or exceed the requirements of AWWA C110. Compact fittings shall be ductile iron meeting or exceeding the requirements of AWWA C153. Fittings shall have the same lining and coating as the pipe specified above. All fittings shall be marked with the weight and shall have distinctly cast upon them the pressure rating, the manufacturer's identification, nominal diameter of openings and the number of degrees or fraction of the circle on all bends. All fittings 4 through 24 inches shall be Class 350. All fittings greater than 24 inches shall be as specified above except they shall be Class 250. Compact fittings shall only be used in sizes 4 through 24 inches. Fittings shall conform to the weights, excluding accessories, and dimension shown in the latest edition of the Handbook of Ductile Iron Pipe and come complete with all joint accessories as required. All accessories (gland gaskets, T-bolts, and nuts) shall be in accordance with AWWA C111. All mechanical joint bolts (T-bolts) shall be Cor-Ten or equal.
7. Contractor shall provide all adapters and fittings such as transition couplings, as determined in the field, necessary to complete all cross connections, whether or not specifically stated in the Contract Drawings and Specifications.
8. All pipes shall be marked with the class, thickness designation, and initials of the manufacturer.
9. If required the manufacturer shall supply the Engineer with certificates of compliance with these Specifications and certification that each piece of ductile iron pipe has been tested at the foundry with the Ball Impression Test, Ring Bending, or equal.
10. Pipe for use with sleeve-type couplings shall be as specified except that the ends shall be plain (without bells or beads). The ends shall be cast or machined at right angles to the axis.

B. INSPECTION, TESTS, AND ACCEPTANCE FOR DUCTILE IRON PIPE

1. All pipe delivered to the job site shall be accompanied by test reports certifying that the pipe and fittings conform to "AWWA Standard for Ductile Iron Pipe, for Water and Other Liquids" (AWWA H3) and (AWWA C151).
2. All tests shall be made in accordance with the methods prescribed by the above mentioned AWWA Standards, and the acceptance or rejection shall be based on the test results.
3. Pipe which does not conform to the requirements of this contract shall be immediately removed and replaced by the Contractor.
4. All ductile iron pipe to be installed under this Contract may be inspected at the foundry for compliance with these Specifications by an independent testing laboratory selected by the Owner. The Contractor shall require the manufacturer's cooperation in these inspections. The cost of foundry inspection of all pipe approved for this Contract, plus the cost of the inspection of a reasonable amount of disapproved pipe, will be borne by the Owner.

C. SLEEVE COUPLINGS FOR DUCTILE IRON PIPE

1. Sleeve couplings and accessories shall be pressure rated at least equal to that of the pipe. Couplings shall be cast iron and shall be Dresser Style 53 or 153, Rockwell Style 441, Baker Series 4245 or acceptable equivalent product. The couplings shall be provided with Cor-Ten bolts and nuts or approved equal.
2. After assembly, all exterior surfaces including the bolts and nuts shall be thoroughly coated with two coats of heavy-duty protective coating. The interior of the coupling shall be epoxy coated. Coating shall be a minimum of 10 mils. and a maximum of 20 mils. dry film thickness thermosetting epoxy.

2.13 HUB AND SPIGOT CAST IRON SOIL PIPE AND FITTINGS

A. Hub and Spigot Cast Iron pipe and fittings shall be manufactured from gray cast iron and shall conform to ASTM A74. Joints shall be made using a compression gasket manufactured from an elastomer meeting the requirements of ASTM C564. Installation shall comply with manufacturer’s recommendations and applicable code requirements.

2.14 PVC DRAINAGE PIPE

A. General: Provide pipes of the following materials of class indicated. Provide pipe fittings and accessories of same materials and class as pipes with joining method, as indicated. The piping shall be manufactured by an established manufacturer of good reputation in the industry and in a permanent plant adapted to meet all the design requirements of the pipe.

B. PVC (Polyvinyl Chloride) Gravity Sewer Pipe and Fittings: ASTM D3034, SDR 35, for elastomeric gasket joints. Pipe 18 to 36 inches in diameter shall conform to ASTM F679, T-1 heavy wall. The pipe shall have a Standard Dimension Ratio (SDR) of 35 and a pipe stiffness of 46 psi.

C. Perforated PVC pipe to be used for all building foundation and footing drain systems.

D. Joints: PVC pipe shall have an integral wall bell and spigot push-on joint with elastomeric gaskets secured in place in the bell of the pipe. The bell shall consist of an integral wall section with solid cross section elastomeric gasket, factory assembled, securely locked in place to prevent displacement during assembly. Pipe joints shall conform to ASTM D3212 and elastomeric gaskets shall conform to ASTM F477.

E. Spigot pipe ends shall be supplied with bevels from the manufacturer to ensure proper insertion. Each spigot end shall have an "assembly stripe" imprinted thereon to which the bell end of the mated pipe will extend upon proper joining of the two pipes.

F. PVC gravity sewer fittings and accessories shall be as manufactured and furnished by the pipe supplier or approved equal and have bell and spigot configurations compatible with that of the pipe.

2.15 CORRUGATED POLYETHYLENE PIPE

A. General: Provide pipes of the following materials of class indicated. Provide pipe fittings and accessories of same materials and class as pipes with joining method, as indicated. The piping shall be manufactured by an established manufacturer of good reputation in the industry and in a permanent plant adapted to meet all the design requirements of the pipe.

1. Corrugated polyethylene pipe shall have an interior surface that is smooth and even, free from roughness, projections, indentations, offsets, or irregularities of any kind.
    a. Pipe shall conform to AASHTO M252, Type S for 4- through 10-inch diameter pipes.
    b. Pipe shall conform to AASHTO M294, Type S or ASTM F2306 for 12- through 60-inch diameter pipes.
    c. Fittings shall conform to AASHTO M252, AASHTO M294 or ASTM F2306. Bell and spigot connections shall utilize a spun-on or welded bell and valley or saddle gasket meeting the watertight joint performance requirements of AASHTO M252, AASHTO M294 or ASTM F2306.
2. Pipe and fittings shall be high-density polyethylene meeting the requirements of ASTM D3350.
3. Pipe units shall have a minimum laying length of 20-feet except as otherwise indicated or allowed by the Engineer.
4. Pipe shall be installed with a minimum 12-inch cover for AASHTO H-20 loading.
5. Slotted CPP shall be used for all retaining wall drain systems.

B. CORRUGATED POLYETHYLENE FLARED END SECTION

1. The pipe shall have an interior surface that is smooth and even, free from roughness, projections, indentations, offsets, or irregularities of any kind. Flared end section shall be high-density polyethylene meeting ASTM D3350 minimum cell classification 213320C. Metal threaded fastening rods shall be stainless steel.

C. JOINTS ON CORRUGATED POLYETHYLENE PIPE

1. The pipe and fitting joints shall be bell-and spigot with watertight gaskets in accordance with the requirements of ASTM D3212.
2. Gaskets shall meet the requirements of ASTM F477. Gaskets shall be installed by the pipe manufacturer and covered with a removable, protective wrap to ensure the gasket is free from debris. A joint lubricant available from the manufacturer shall be used on the gasket and bell during assembly.
3. Pipe entrances at catch basins shall be made with a mortar made with Type II cement. Mortar mixture shall follow instructions provided by cement manufacturer. Pipe connections at drain manholes and water quality structures shall be made with integral flexible rubber sleeves and Corrugated Pipe Adapters designed for use with the pipe and sleeves.

2.16 REINFORCED CONCRETE PIPE (CLASS IV; 12 THROUGH 48 INCHES)

A. General: Provide pipes of the following materials of class indicated. Provide pipe fittings and accessories of same materials and class as pipes with joining method, as indicated. The piping shall be manufactured by an established manufacturer of good reputation in the industry and in a permanent plant adapted to meet all the design requirements of the pipe.

1. The pipe shall have an interior surface, which is smooth and even, free from roughness, projections, indentations, offsets, or irregularities of any kind. Pipe shall conform to ASTM "Specifications for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe," Designation: C76 and shall be Wall B for the Class IV and V, as noted on the drawings, and with additions and exceptions as follows:
2. Type II cement shall be used unless otherwise approved by the Engineer. Admixtures shall not be used except with prior approval of the Engineer.
3. Elliptical reinforcement will not be permitted. Longitudinal reinforcement shall be continuous. Reinforcement shall have a minimum cover of ¾ inch. Pipe shall have no lifting holes.
4. Absorption shall be as specified under "Tests of Materials and Pipe Units."
5. Pipes manufactured by the centrifugal process or in vertical forms shall be cast of wet mix concrete. Concrete cast in vertical forms shall be consolidated by internal or external mechanical vibration or both. The vibrating equipment shall be operated at high speed (more than 5,000 rpm) and have a low amplitude. Pipes manufactured by the modified packer process shall have a supplementary concrete densification operation that shall assure the attainment of full bond between reinforcement and concrete and also eliminate any displacement of the reinforcement. Additional passes with the revolving packerhead or the use of additional vibrators attached to the platform or exterior forms will not be acceptable.
6. Pipe units shall have a minimum laying length of 8-feet except as otherwise indicated or allowed by the Engineer.
7. Pipe may be rejected for any of the following reasons:
    a. Exposure of any wires, positioning spacers or chairs used to hold the reinforcement cage in position, or steel reinforcement in any surface of the pipe, except as permitted by Section 8.2 of ASTM C76.
    b. Transverse reinforcing steel found to be in excess of 1/4-inch out of specified position after the pipe is molded.
    c. Any shattering or flaking of concrete as a crack.
    d. Voids, with the exception of a few minor bugholes, on the interior and exterior surfaces of the pipe exceeding 1/4-inch in depth, unless properly and soundly pointed with mortar or other approved material.
    e. A hollow spot (identified by tapping the internal surface of the pipe) which is greater than 30-inches in length or wider than 3 times the specified wall thickness.
    f. Defects that indicate imperfect molding of concrete; or any surface defect indicating honeycomb or open texture (rock pockets) greater in size than area equal to a square with a side dimension of 2½ times the wall thickness or deeper than two times the maximum graded aggregate size; or local deficiency of cement resulting in loosely bonded concrete.
    g. Any of the following:
        1) A crack having a width of 0.005 to 0.01-inches throughout a continuous length of 36-inches or more.

2) A crack having a width of 0.0 to 0.03-inches or more throughout a continuous length of 1-foot or more.
3) Any crack greater than 0.005-inches extending through the wall of the pipe and having a length in excess of the wall thickness.
4) Any crack showing two visible lines of separation for a continuous length 2-feet or more, or an interrupted length of 3-feet or more anywhere in evidence, both inside and outside.
5) Cracks anywhere greater than 0.03-inches in width.

h. Application of any wash coat of cement or grout to the pipe will not be permitted without approval of the Engineer. Any pipe dressing procedures shall be subject to the approval of the Engineer.

B. Joints on Reinforced Concrete Pipe:

1. Pipe joints for all reinforced concrete pipe shall be of the rubber gasket type in which the gaskets are in compression and which will permit both longitudinal and angular movement. Each unit of pipe shall be provided with proper ends made of concrete formed true to size and formed on machined rings to ensure accurate joint surfaces.
2. Joints and gaskets for pipe shall be the O-ring gasket type and shall conform to the requirements of ASTM C443 and the additional requirements specified.
3. Joints shall be of such design that when tested under an average internal hydrostatic pressure of 13 pounds per square inch for a period of 10 minutes, no visible leakage will result. The diameters of the joint surfaces which compress the gasket shall not vary from the true diameters by more than 1/16-in or the amount permitted by the appropriate above-mentioned ASTM Standard Specifications, whichever is less.
4. Gaskets shall be of a composition and texture which is resistant to common ingredients of sewage, industrial wastes, and groundwater, and which will endure permanently under the conditions likely to be imposed by this service. Gaskets shall be the product of a manufacturer regularly engaged in the manufacture of rubber gaskets for pipe joints.

C. Flared End Sections: Reinforced Concrete Pipe flared end sections shall conform to requirements of AASHTO M170, minimum Class IV.

2.17 FILTER FABRIC

A. Filter Fabric used as a drainage medium shall be a needle-punched, non-woven geotextile made from polypropylene or polyethylene filaments or yarns.

B. Filter fabric shall be inert to organic chemicals commonly encountered in the soil.

C. Filter fabric shall be meet AASHTO M288 Survivability Class 2 Standards.

D. The edges of filter fabric shall overlap a minimum of one foot.

E. Filter fabric shall be in compliance with the following properties, measured as per the referenced test methods:

PROPERTY	Required Value	TEST METHOD
Grab Tensile Strength	160 lbs. (min.)	ASTM D 4632
Elongation @ Failure	50% (min.)	ASTM D 4632
Trapezoidal Tear Strength	60 lbs. (min.)	ASTM D 4533

PROPERTY	Required Value	TEST METHOD
CBR Puncture Strength	410 lbs. (min.)	ASTM D 6241
Permittivity	1.5 sec^{-1} (min.)	ASTM D 4491
Water Flow Rate	110 gal./min./SF (min.)	ASTM D 4491
Apparent Opening Size	#70 Standard US Sieve	ASTM D 4751
U.V. Radiation Stability	70% (min.)	ASTM D 4355

2.18 CRUSHED STONE

A. Crushed stone shall consist of durable crushed rock or durable crushed gravel stone, free from ice and snow, sand, clay, loam, or other deleterious or organic material. The crushed stone shall be uniformly blended and shall conform to the following requirements.

Percent Passing by Weight		
Sieve Size	**3/4-inch Stone**	**1/2-inch Stone**
1-inch	100	---
3/4-inch	90-100	---
5/8-inch	---	100
1/2-inch	10-50	85-100
3/8-inch	0-20	15-45
No. 4	0-5	0-15
No. 8	---	0-5

2.19 DRAIN COUPLINGS

A. Drain Couplings shall be pressure rated at least equal to that of the pipe. The coupling sleeve, shall be 1/4-inch minimum thickness elastomeric polyvinylchloride with a minimum tensile strength of 1500 psi. The sleeve shall fit snugly onto the pipe to be joined and be resistant to common chemicals present in storm water. Adjustable pipe clamps shall consist of a slotted band that mate with the worm gear screw and a screw housing all manufactured of stainless steel, and suitable for underground service.

2.20 CLEANOUTS

A. General: Provide cast-iron ferrule and countersunk brass cleanout plug, with round cast-iron access frame and heavy-duty, secured, scoriated cast-iron cover.

B. The drain cleanouts shall be minimum 6-inch diameter or sized to match the service pipe, whichever is greater. The cleanout shall be complete with a flush mount over. The cleanout cover shall be clearly marked “DRAIN” and shall be minimum eight inches in diameter or two inches greater than the cleanout size, whichever is greater. Cleanouts shall include a watertight cap.

2.21 IDENTIFICATION

A. Detectable Underground Warning Tapes: Acid and alkali-resistant polyethylene plastic film warning tape, 6-inches wide by 4-mils. minimum thickness, with continuously printed caption in black letters "CAUTION - xxxxx LINE BURIED BELOW." The text and color of the tape shall be as shown in the table below. The tape shall have a metallic core encased in a

protective jacket for corrosion protection and be detectable by a metal detector when the tape is buried up to 2.5-feet deep.

Color	Utility
Safety Red	Electric
High Visibility Safety Yellow	Gas, Oil, Steam
Safety Alert Orange	Telephone, Communications, Cable Television
Safety Precaution Blue	Water System, Irrigation
Safety Green	Sanitary Sewer, Storm Sewer

PART 3 – EXECUTION

3.1 GENERAL INSTALLATION

A. General: General Locations and Arrangements: Contract Drawings indicate the general location and arrangement of the underground storm drainage system piping. Location and arrangement of piping layout take into account many design considerations. Install the piping as indicated, to the extent practical. Any modifications to the layout of the storm drainage system shall be submitted to the Engineer for review and approval at least five days prior to the start of the affected work.

B. Install piping beginning at low point of systems, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install gaskets, seals, sleeves, and couplings in accordance with manufacturer's recommendations, accepted practices, and utility owner’s requirements. Maintain swab or drag in line and pull past each joint as it is completed.

C. All pipe shall be laid in the dry. Adequate measures shall be taken to prevent floatation of pipe in the trench.

D. Whenever encountered within the trench, existing abandoned water, sewer, and/or drain lines shall be removed within the trench limits, unless otherwise noted. The remaining portion of the abandoned lines shall be plugged at all open ends.

E. When bell and spigot pipes are used, bell holes shall be dug in the bedding to accommodate the bells. They shall be deep enough to ensure that the bell does not bear on the bottom of the hole but shall be excessively wide in the longitudinal direction of the installation.

F. Use manholes for changes in direction, except where a fitting is indicated. Use fittings for branch connections, except where direct tap into an existing storm drain is indicated.

G. Use proper size increasers, reducers, and couplings, where different size or material of pipes and fittings are connected. Reduction of the size of piping in the direction of flow is prohibited without the written approval of the Engineer.

H. Install piping pitched down in direction of flow as indicated on the Contract Drawings.

I. Extend storm drainage system piping to connect to building drain services, of sizes and in locations indicated on the Contract Drawings.

J. Install piping in accordance with governing authorities having jurisdiction, except where more stringent requirements are indicated.

K. Acceptance of Pipe: Acceptance will be on the basis of tests specified herein before. The quality of all materials used in the pipe, the process of manufacture, and the finished pipe shall be subject to review by the Engineer. Inspection may be made at the place of manufacture, or on the work site after delivery or at both places and the pipe shall be subject to rejection at any time on account of failure to meet any of the specification requirements, even though sample pipe units may have been accepted as satisfactory at the place of manufacture. All pipe which is rejected shall be immediately removed from the project site by the Contractor.

L. Pipe Storage: Pipe sections shall not be stored on areas over the newly laid pipe or other pipelines which might be damaged by the superimposed load, and storage sections shall be restricted to approved areas.

M. Handling Pipe: Each pipe unit shall be handled into its position in the trench only in such manner and by such means, as the Engineer accepts as satisfactory. The Contractor will be required to furnish suitable devices to permit satisfactory support of all parts of the pipe unit when it is lifted.

N. Laying Pipe: Except where a concrete cradle or envelope is required, the pipe shall be laid in a crushed stone cradle. In trenches, no blocking or supporting of the piping by concrete, stones, bricks, wooden wedges, or method other than bedding the pipe on crushed stone will be permitted. Each length of pipe shall be shoved home against the pipe previously laid and held securely in position. Joints shall not be "pulled" or "cramped" without approval of the Engineer.

O. Jointing Pipe: After the pipe are aligned in the trench and are ready to be jointed, all joint surfaces shall be cleaned.

P. Alignment and Placement: All pipe shall be laid with extreme care as to grade and alignment. Each pipe shall be so laid as to form a close joint with the next adjoining pipe and bring the inverts continuously to the required grade.

1. Stakeout of drain work and setting of line and grade is the responsibility of the Contractor.
2. The Contractor shall establish centerline and offset stakes at each manhole, plus one intermediate centerline and offset stake as a check point between manholes. Laser aligning shall not be used to establish a continuous line in excess of 400-feet.

Q. Cleaning: Care shall be taken to prevent earth, water, and other materials from entering the pipeline. As soon as possible after the pipe and manholes are completed, the Contractor shall clean out the pipeline and manholes being careful to prevent soil, water and debris from entering any existing drainage system.

1. Place plugs in end of uncompleted conduit at end of day or whenever work stops.
2. Flush lines between manholes to remove collected debris.

R. Review of Completed Storm Drain System: The completed drain system shall be visually inspected by the Owner's Representative. If the visual observation of the completed drain or any part thereof shows any pipe, manhole, or joint to be of defective work or material, the defect shall be replaced or repaired as directed by the Engineer or the Owner's Representative. The Contractor shall coordinate and provide site access for inspection.

3.2 PLACEMENT OF DUCTILE IRON PIPE AND FITTINGS

A. Care shall be taken in loading, transportation, and unloading to prevent injury to the pipe or coatings. Pipe or fittings shall not be dropped. All pipe and fittings shall be examined before

placement, and no piece shall be installed which is found to be defective. Any damage to the pipe coatings shall be repaired as directed by the Engineer.

B. If any defective pipe is discovered after it has been placed, it shall be removed and replaced with a sound pipe in a satisfactory manner by the Contractor, at his own expense. All pipe and fittings shall be kept clean until they are used in the work, be thoroughly cleaned before placement, and when placed, shall conform to the lines and grades required. Ductile iron pipe and fittings shall be installed in accordance with requirements of AWWA Standard Specification C600 except as otherwise provided herein. A firm even bearing throughout the length of the pipe shall be constructed by compacting gravel borrow around the pipe and up to the springline.

1. Blocking will not be permitted.

C. All pipes shall be sound and clean before placement. When pipe laying is not in progress, including lunchtime, the open ends of the pipe shall be temporarily closed by watertight plug or other acceptable means. Alignment shall be maintained during placement. The deflection at joints shall not exceed sixty percent of that recommended by the manufacturer. Fittings, in addition to those shown on the plans, shall be provided, if required, in crossing utilities, which may be encountered upon opening the trench. Solid sleeves shall be used only where allowed by the Engineer.

D. When cutting pipe is required, the cutting shall be done by machine, leaving a smooth cut at right angles to the axis of the pipe. Cut ends of pipe to be used with a push-on type bell shall be beveled to conform to the manufactured spigot end.

E. The Contractor shall take care not to damage pipe by impact, bending, compression, or abrasion during handling, and installation. Joint ends of pipe especially shall be kept clean.

F. Pipe shall be stored above ground at a height no greater than 5 feet and with even support for the pipe barrel.

G. Only nylon protected slings shall be used for handling the pipe. No hooks, chains or bare cables will be permitted.

H. Gaskets shall be shipped in cartons and stored in a clean area, away from grease, oil, heat, direct sunlight and ozone producing electric motors.

I. Jointing of ductile iron push on pipe and fittings shall be done in accordance with the printed recommendations of the manufacturer and as specified. The last 8 inches of the outside of the spigot end of pipe and the inside of the bell end of pipe shall be thoroughly cleaned. The joint surfaces and the gasket shall be painted with a lubricant just prior to making up the joint. The spigot end shall then be gently pushed home into the bell. The position of the gasket shall be checked to ensure that the joint has been properly made and is watertight. Care shall be taken not to exceed the manufacturer's recommended maximum deflection allowed for each joint.

1. Jointing Ductile Iron Pipe (Push-On Type): Push-on joints shall be made in strict accordance with the manufacturer's instructions. Pipe shall be laid with bell ends looking ahead. A rubber gasket shall be inserted in the groove of the bell end of the pipe, and the joint surfaces cleaned and lubricated. The plain end of the pipe to be entered shall then be inserted in alignment with the bell of the pipe to which it is to be joined, and pushed home with a jack or by other means. After joining the pipe, a metal feeler shall be used to make certain that the rubber gasket is correctly located.

2. Jointing Mechanical Joint Fittings: Mechanical joints at fittings and where designated shall be installed in accordance with the "Notes on Method of Installation" under ANSI

Specification A 21.11 and the instructions of the manufacturer. To assemble the joints in the field, the Contractor shall thoroughly clean the joint surfaces and rubber gasket with soapy water before tightening the bolts. Bolts shall be tight to the specified torque. Under no condition shall extension wrenches or pipes over handles or ordinary ratchet wrenches be used to secure greater leverage.

J. Installation and jointing of ductile iron pipe shall be in accordance with AWWA C600, Sections 9b and 9c, latest revision, as applicable.

K. Ductile iron pipe installed within 5-feet of gas lines shall be fully encased with polyethylene material. Polyethylene shall be 8 millimeters thick and comply with AWWA C 105.

3.3 PVC PIPE

A. General: Install piping in accordance with governing authorities having jurisdiction, except where more stringent requirements are indicated.

B. PIPE HANDLING

1. All pipe and fittings shall be carefully handled from the truck onto the ground and into the trench or excavation so as to prevent damage to the pipe. Pipes shall be kept free of dirt and foreign material, especially on the inside. Joint ends of pipe shall especially be kept clean.
2. Pipe stored on site shall be protected from heat and direct sun light and shall be suitably ventilated.
3. Pipe or fittings shall not be dropped. All pipe or fittings shall be examined before laying, and no piece shall be installed which is found to be defective.

C. ALIGNMENT AND PLACEMENT OF PVC PIPE

1. Bedding material for the pipe must be installed with care in the area around the pipe. Bedding material must be placed to provide uniform and adequate support under pipe. Do not use blocking to bring pipe up to grade.
2. Provide bell holes at each joint to permit joint to be assembled properly while maintaining uniform pipe support.
3. Place and consolidate the bedding material under the pipe haunch to provide adequate side support while avoiding both vertical and lateral displacement of pipe.
4. Initial backfill must be completed to a point at least 12-inches over the top of the pipe and be hand placed. Use little or no tamping of initial backfill directly over the top of pipe. Compaction methods may be utilized during final backfilling.
5. No length of pipe shall be laid until the proceeding lengths of pipe have been thoroughly embedded in place, to prevent movement or disturbance of the pipe alignment.
6. Full lengths of pipe shall be used in the installation except that partial lengths may be used at the entrance to structures, and to accommodate the required locations of service connection fittings.
7. Pipe entrances to structures shall be cut flush with the inside face of the structure, and cut ends of the pipe surface within the structure shall be properly rounded and finished so that there will be no protrusion, ragged edges or imperfections that will impede or affect the hydraulic characteristics of the sewage flow. The method of cutting and finishing shall be subject to the approval of the Engineer.
8. The Contractor shall protect the installation at all times during construction. The movement of construction equipment, vehicles and loads over and adjacent to any pipe shall be performed at the Contractor’s own risk.

9. Drain pipes shall be laid to the required grades by use of a laser and target system, unless otherwise specifically approved by the Engineer.
10. Jointing of PVC drain pipe and fittings shall be done in accordance with the printed recommendations of the manufacturer and as specified. The bell end of the pipe shall be thoroughly cleaned. The joint surfaces and the gasket shall be lubricated prior to making up the joint. The position of the gasket shall be checked to ensure the joint has been properly made and is watertight. Care shall be taken not to exceed the manufacturer's recommended maximum deflection allowed for each joint.
11. PVC pipe shall be pushed home by hand or with the use of bar and block. The use of power equipment, such as a backhoe bucket, is not acceptable.
12. Field-cut pipe ends shall be cut square and the pipe surface beveled to the size and shape of a factory-finished beveled end. All sharp edges shall be rounded off.

3.4 INSTALLATION OF REINFORCED CONCRETE PIPE AND PIPE FITTINGS

A. General: Install piping in accordance with ASTM D2321, the governing authorities having jurisdiction of the utility, and the manufacturer’s instructions, except where more stringent requirements are required by the Contract Documents.

B. Acceptance of Pipe: Acceptance will be on the basis of tests specified hereinbefore. The quality of all materials used in the pipe, the process of manufacture, and the finished pipe shall be subject to review by the Engineer. Inspection may be made at the place of manufacture, or on the work site after delivery or at both places and the pipe shall be subject to rejection at any time on account of failure to meet any of the specification requirements, even though sample pipe units may have been accepted as satisfactory at the place of manufacture. All pipe which is rejected shall be immediately removed from the project site by the Contractor at no cost to the Owner.

C. Pipe Storage: Pipe sections shall not be stored on areas over the newly laid pipe or other pipelines which might be damaged by the superimposed load, and storage sections shall be restricted to approved areas.

D. Laying Pipe: Except where a concrete cradle or envelope is required, the pipe shall be laid in a crushed stone cradle. In trenches, no blocking or supporting of the piping by concrete, stones, bricks, wooden wedges, or method other than bedding the pipe on crushed stone will be permitted. Each length of pipe shall be shoved home against the pipe previously laid and held securely in position. Joints shall not be "pulled" or "cramped" without approval of the Engineer.

E. Jointing Pipe: After the pipes are aligned in the trench and are ready to be jointed, all joint surfaces shall be cleaned.

F. Alignment and Placement: All pipes shall be laid with extreme care as to grade and alignment. Each pipe shall be so laid as to form a close joint with the next adjoining pipe and bring the inverts continuously to the required grade.
   1. Stakeout of drain work and setting of line and grade is the responsibility of the Contractor.
   2. The Contractor shall establish centerline and offset stakes at each manhole, plus intermediate centerline and offset stakes as needed to ensure proper alignment and grade. Laser aligning shall not be used to establish a continuous line in excess of 400-feet.

G. Cleaning: Care shall be taken to prevent earth, water, and other materials from entering the pipeline. As soon as possible after the pipe and manholes are completed, the Contractor shall clean out the pipeline and manholes being careful to prevent soil, water, and debris from entering any existing Drain.

1. Place plugs in end of uncompleted conduit at end of day, or whenever work stops.
2. Flush lines between manholes to remove collected debris.

H. Review of Completed Reinforced Concrete Pipe System: If the visual observation of the completed drain or any part thereof shows any pipe, manhole, or joint to be of defective work or material the defect shall be replaced or repaired as directed at no cost to the Owner. The visual observation shall be conducted by the Engineer and any defects shall be as identified by such. The Contractor shall coordinate and provide site access for the Owner.

3.5 INSTALLATION OF CORRUGATED POLYETHYLENE PIPE AND PIPE FITTINGS

A. General: Install Corrugated Polyethylene Pipe in accordance with ASTM D2321 and governing authorities having jurisdiction, except where more stringent requirements are indicated.

B. Acceptance of Pipe: Acceptance will be on the basis of tests specified herein before. The quality of all materials used in the pipe, the process of manufacture, and the finished pipe shall be subject to review by the Engineer. Inspection may be made at the place of manufacture, or on the work site after delivery or at both places and the pipe shall be subject to rejection at any time on account of failure to meet any of the specification requirements, even though sample pipe units may have been accepted as satisfactory at the place of manufacture. All pipe which is rejected shall be immediately removed from the project site by the Contractor.

C. Pipe Storage: Pipe sections shall not be stored on areas over the newly placed pipe or other pipelines which might be damaged by the superimposed load, and storage sections shall be restricted to approved areas.

D. Handling Pipe: Each pipe unit shall be handled into its position in the trench only in such manner and by such means, as the Engineer accepts as satisfactory. The Contractor will be required to furnish suitable devices to permit satisfactory support of all parts of the pipe unit when it is lifted.

E. Alignment and Placement: All pipe shall be placed with extreme care as to grade and alignment. Each pipe shall be so placed as to form a close joint with the next adjoining pipe and bring the inverts continuously to the required grade.

1. Stakeout of drain work and setting of line and grade is the responsibility of the Contractor.
2. The Contractor shall establish centerline and offset stakes at each manhole, plus intermediate centerline and offset stake as needed to ensure proper alignment and grade between manholes. Laser aligning shall not be used to establish a continuous line in excess of 400-feet.
3. Bedding material for the pipe must be installed with care in the area around the pipe. Bedding material must be placed to provide uniform and adequate support under pipe. Do not use blocking to bring pipe up to grade. Bedding shall be crushed stone.
4. Provide bell holes at each joint to permit joint to be assembled properly while maintaining uniform pipe support.

5. Place and consolidate the bedding material under the pipe haunch to provide adequate side support while avoiding both vertical and lateral displacement of pipe.
6. Initial backfill must be completed to a point at least 12-inches over the top of the pipe and be hand placed. Use little or no tamping of initial backfill directly over the top of pipe. Compaction methods may be utilized during final backfilling.
7. No length of pipe shall be laid until the proceeding lengths of pipe have been thoroughly embedded in place, to prevent movement or disturbance of the pipe alignment.
8. Full lengths of pipe shall be used in the installation except that partial lengths may be used at the entrance to structures, and to accommodate the required locations of service connection fittings.
9. Pipe entrances to structures shall be cut flush with the inside face of the structure, and cut ends of the pipe surface within the structure shall be properly finished so that there will be no protrusion, ragged edges or imperfections that will impede or affect the hydraulic characteristics of the stormwater flow. The method of cutting and finishing shall be subject to the approval of the Engineer.
10. The Contractor shall protect the installation at all times during construction. The movement of construction equipment, vehicles and loads over and adjacent to any pipe shall be performed at the Contractor's own risk.
11. Jointing of pipe and fittings shall be done in accordance with the printed recommendations of the manufacturer and as specified. The bell end of the pipe shall be thoroughly cleaned. The joint surfaces and the gasket shall be lubricated prior to making up the joint. The position of the gasket shall be checked to ensure the joint has been properly made and is watertight. Care shall be taken not to exceed the manufacturer's recommended maximum deflection allowed for each joint.
12. Each length of pipe shall be pushed home by hand or with the use of bar and block. The use of power equipment, such as a backhoe bucket, is not acceptable.
13. Field-cut pipe ends shall be cut square.

3.6 INSTALLATION OF DRAIN MANHOLES AND CATCH BASINS

A. The bases shall be supported on a compacted level foundation of gravel borrow a minimum of 12 inches thick. Crushed stone may be substituted for gravel borrow if field conditions at the bottom of the excavation are wet.

1. The Contractor shall install the manholes and catch basins as soon as the pipe laying reaches the location of the structures.
2. The Contractor shall accurately locate each manhole and catch basin and set accurate templates to conform to the required line and grade. Any manhole or catch basin which is not installed in the correct location or oriented improperly shall be removed and rebuilt in its proper location, alignment, and orientation at no additional cost to the Owner.
3. Manhole risers and tops shall be installed using approved butyl rubber sealant or rubber gasket for sealing joints of manhole risers and tops; jointing shall be performed in accordance with the manufacturer's recommendations. Manhole risers and tops shall be installed level and plumb. Water shall not be permitted to rise over newly made joints, nor until after inspection as to their acceptability. All jointing shall be done in a manner to ensure watertight joints.
4. Openings shall be provided in the precast concrete manhole sections to receive entering pipes and these openings shall be made at the place of manufacture. Pipe entrances at catch basins shall have plain beveled openings to accept the type of pipe specified and to be sealed with non-shrink grout. Grout mixture shall follow instructions provided by manufacturer. Pipe connections at drain manholes shall be made as

indicated on the Drawings with either non-shrink grout or integral flexible rubber sleeves and Corrugated Pipe Adapters designed for use with the pipe and sleeves. For grouted joints, surface between pipe and wall shall be completely filled with non-shrink grout and troweled to provide a smooth surface conforming to both the outside and inside structure wall.

5. Care shall be taken to ensure that the openings are made to permit setting of the entering pipe at its correct elevation as indicated or directed. Manhole risers and tops shall be installed so that the manhole steps shall be in alignment.
6. All holes used for handling shall be thoroughly plugged with non-shrink grout.
7. Cutting or tampering in the field, for purpose of creating new sidewall openings or altering existing openings, will not be permitted except at the discretion of the Engineer or if necessary concrete block manhole(s) shall be used.
8. All interior manhole joints where the sealing material is not flush with the inside wall shall be grouted with non-shrink mortar and finished by hand/wet-brush.
9. A cast-in-place concrete invert shelf and channel shall be poured and shaped to the lower half of the pipes
10. Clean all debris, mortar, and soil from the bottom of all structures prior to final acceptance of the project.

3.7 SETTING MANHOLE FRAMES AND COVERS AND CATCH BASIN FRAMES AND GRATES

A. Manhole and catch basin frames shall be set with tops conforming accurately to the grade of the pavement or finished ground surface or as indicated on the Contract Drawings or as directed.

B. Brick shall be used to bring the frames to the required elevation.

1. Frames shall be set centered with the opening in the top of the precast structure on two to four courses of brick in a full bed of mortar. A thick ring of mortar extending to the outer edge of brick or concrete shall be placed all around the bottom flange of the cast iron frame. The mortar shall be smoothly finished to a height of 5 inches above the flange for 8-inch frames and sloped to shed water away from the frame.
2. Completed brick installation shall be coated with mortar at least a ¾ inch thick on the outside to provide a fully sealed and watertight collar between the top manhole section and the cover frame.
3. Only clean bricks shall be used in brick work to adjust frame elevations. The brick shall be moistened by suitable means.

C. Manhole covers shall be left in place in the frame until completion of other work at the manholes.

D. Where directed, the castings shall be temporarily set at such grades as to provide drainage during construction. The castings of structures located within the pavement area shall not be completely set to the established grade until the bottom course of pavement has been laid. The final setting of all other casting shall be performed at the proper stage of construction.

3.8 CHANGE IN TYPE

A. When an existing catch basin is to be converted to a manhole, the frame and grate shall be carefully removed and a new frame and cover installed to finish grade. If in the opinion of the Engineer the existing casting is reusable, it may be reused in the work, otherwise, it shall be disposed of off-site.

1. The sump of the catch basin shall be thoroughly cleaned of debris and silt and the interior surfaces brushed to remove contaminants.
2. The sump shall be thoroughly filled with compacted gravel to a level no greater than 6 inches below the pipe invert. A cast-in-place concrete invert shelf and channel shall be poured and shaped to the lower half of the pipes.
3. New openings in existing structures shall be carefully cut with power saws of the proper size and elevation to accept the new connection. Damage to the structure caused by the Contractor's construction methods shall be repaired at no additional cost.

3.9 STRUCTURE REBUILT

A. When in the opinion of the Engineer existing masonry structure walls show deterioration, the structure shall be rebuilt. The casting and deteriorated masonry shall be removed in a careful and neat manner until only a sound condition remains. Concrete blocks shall be used to rebuild the structure. The new masonry construction, replacing of the casting, and other incidental work shall be performed as specified above.
   1. The Contractor's base bid shall include rebuilding [ ] vertical linear feet of existing manhole or catch basin structures.

3.10 INSTALLATION OF WATER QUALITY STRUCTURES

A. Contractor shall take appropriate action to protect all structure components throughout the installation and construction process. Care shall be taken in loading, transporting, and unloading to prevent damage to materials during storage and handling.

B. Install water quality structures per manufacturer's specifications.

C. The installation of a precast concrete structure should conform to ASTM C 891 for the construction of manholes.

D. The precast concrete structure shall be installed in sections in the following sequence:
   1. Aggregate Base: Structure shall be supported on a compacted level foundation of gravel borrow or crushed stone a minimum of 12 inches thick.
   2. Base Slab
   3. Treatment chamber section(s)
   4. Transition slab (if required)
   5. Bypass Section
   6. Connect inlet and outlet pipes
   7. Riser section and/or transition slab (if required)
   8. Maintenance rider section(s) (if required)
   9. Frame and access cover

E. The precast base shall be placed level at the specified grade. The entire base should be in contact with the underlying compacted granular material. Subsequent sections, complete with joint seals, shall be installed in accordance with the precast concrete manufacturer's installation requirements.

F. Adjustment of the stormwater quality treatment structure can be performed by lifting the upper sections free of the excavated area, re-leveling the base, and re-installing the sections. Damaged sections and gaskets shall be repaired or replaced as necessary. Once the

stormwater quality treatment structure has been constructed, any lift holes shall be plugged watertight with mortar or non-shrink grout.

G. Internal components requiring field installation shall be installed by the Contractor in accordance with the manufacturer's specifications and installation requirements.

H. Inlet and outlet pipes should be securely set into the structure using approved pipe seals (flexible boot connections) so that the structure is watertight.

I. Grade rings shall be installed to set the frame and cover at the required elevation. The grade rings shall be laid in a full bed of mortar with successive units being joined using sealant recommended by the manufacturer. Frames for the cover shall be set in a full bed of mortar at the elevation specified.

J. If precast tank sections are to be field assembled, adequate waterproofing shall be used at the joint to resist the waterhead at that joint.

3.11 INSTALLATION OF PRECAST CONCRETE TANKS AND VAULTS

A. The bases shall be supported on a compacted level foundation of gravel borrow a minimum of 12 inches thick. Crushed stone may be substituted for gravel borrow if field conditions at the bottom of the excavation are wet.

B. The precast base shall be placed level at the specified grade. The entire base should be in contact with the underlying compacted granular material. Subsequent sections, complete with joint seals, shall be installed in accordance with the precast concrete manufacturer's recommendations. Structure sections shall be installed level and plumb. Water shall not be permitted to rise over newly made joints, nor until after inspection as to their acceptability. All jointing shall be done in a manner to ensure watertight joints.

C. Adjustment of the structure can be performed by lifting the upper sections free of the excavated area, re-leveling the base, and re-installing the sections. Damaged sections and gaskets shall be repaired or replaced as necessary. Once the structure has been constructed, any lift holes shall be plugged watertight with mortar or non-shrink grout. Any precast structure which is not installed in the correct location or oriented improperly shall be removed and rebuilt in its proper location, alignment, and orientation at no additional cost to the Owner.

D. Inlet and outlet pipes should be securely set into the structure using approved pipe seals (flexible boot connections, where applicable) so that the structure is watertight. Care shall be taken to ensure that the openings are made to permit setting of the entering pipe at its correct elevation as indicated or directed. Cutting or tampering in the field, for purpose of creating new sidewall openings or altering existing openings, will not be permitted.

E. Grade rings shall be installed to set the frame and cover at the required elevation. The grade rings shall be laid in a full bed of mortar with successive units being joined using sealant recommended by the manufacturer. Frames for the cover shall be set in a full bed of mortar at the elevation specified.

F. Clean all debris, mortar, and soil from the bottom of all structures prior to final acceptance of the project.

3.12 AREA DRAINS

A. Install area drains per manufacturer specifications.

B. The specified PVC surface drainage inlet shall be installed using conventional flexible pipe backfill materials and procedures. The backfill material shall be crushed stone or other granular material meeting the requirements of class 2 material as defined in ASTM D2321. Bedding and backfill for surface drainage inlets shall be placed and compacted uniformly in accordance with ASTM D2321. The drain basin body will be cut at the time of the final grade. No brick, stone or concrete block will be required to set the grate to the final grade height.

C. For H-20 load rated installations, a concrete ring shall be poured under and around the grate and frame as indicated on the Drawings.

3.13 INLINE DRAINS

A. The specified PVC surface drainage inlet shall be installed using conventional flexible pipe backfill materials and procedures. The backfill material shall be crushed stone or other granular material meeting the requirements of class 1 or class 2 material as defined in ASTM D2321. Bedding and backfill for surface drainage inlets shall be well placed and compacted uniformly in accordance with ASTM D2321. The drain basin body will be cut at the time of the final grade. No brick stone or concrete block will be required to set the grate to the final grade height. For H-20 load rated installations, a concrete ring will be poured under and around the grate and frame. The concrete slab must be designed taking into consideration local soil conditions, traffic loading, and other applicable design factors. For other installation considerations such as migration of fines, ground water, and soft foundations refer to ASTM D2321 guidelines.

3.14 TRENCH DRAINS

A. Install trench drain structures per manufacturer specifications.

3.15 DRAIN COUPLINGS

A. Couplings which are factory manufactured shall be installed at all connections from existing pipe to proposed pipe unless the existing pipe is the same material as the proposed pipe and the bell and spigot end of the pipes to be connected are compatible and free from defects. All drain couplings shall be installed in accordance with the manufacturer's recommendations for the types of pipe to be connected.

3.16 CLEANOUTS

A. Install cleanouts and extensions from drain pipe to cleanout at grade as indicated on the Contract Drawings. Set cleanout frame and cover in concrete 18 by 18 by 6-inches deep, except where location is in bituminous or concrete paving. Set top of cleanout 1-inch above surrounding earth grade or flush with grade when installed in paving.

3.17 TAP CONNECTIONS

A. Make connections to existing underground drainage structures, so that finished work will conform as nearly as practicable to requirements specified for new work. The contractor shall verify the location, size, invert, and type of existing pipes at all points of connection prior to make the connections.

B. Make branch connections from side into existing piping by installing a wye or T-wyes, and couplings manufactured for use with the same type of pipe as indicated on the Contract Drawings. The Contractor shall install a 45-degree wye branch or 90-degree tee fittings in the drain pipe at all locations where storm service pipe connections are shown on the Drawings. Connections of the storm service pipes shall be made into the wye branches or

tees by means of 45-degree bends. The connections shall be made thoroughly watertight and concrete shall be placed under each connection to bear on undisturbed earth and firmly support the connection.

C. Protect existing piping and structures to prevent concrete or debris from entering while making tap connections. Remove debris, concrete, or other extraneous material that may accumulate.

D. Connections into existing drainage facilities shall be performed in accordance with the requirements of the City of Worcester The Contractor shall comply with all such requirements, including securing of all required permits and paying the costs thereof.

3.18 BACKFILLING

A. General: Conduct excavation and backfill operations for structure and pipe installations in accordance with Section 312000 – EARTH MOVING, local requirements, and the contract documents.

B. Initial backfill shall be placed evenly on both sides of the pipe to distribute the load and not to cause movement or deflection of the pipe.

3.19 INSTALLATION OF IDENTIFICATION

A. Install continuous plastic underground warning tape during back-filling of trench for underground storm drainage system piping. Locate tape two-feet below finished grade, directly over piping.

3.20 FIELD TESTING OF CORRUGATED POLYETHYLENE PIPING

A. The pipe shall be cleaned and visually inspected for offsets and obstructions prior to testing.

B. The total length of each pipe installed on the project shall be tested or inspected for deflection. Conveyance pipes connecting at both ends to concrete drainage structures (catch basins, manholes, outlet control structures, water quality structures, etc.) shall be mandrel tested. Deflection of pipes used for stormwater detention/retention/infiltration systems, and pipes connecting to wye connections, building connections, trench drains, and other connections that do not allow mandrel testing shall be verified by visual inspection by the Owner’s Representative during installation.

C. Mandrel tests shall be performed by the Contractor and observed by the Owner’s Representative not sooner than 20 days after completion of installation and compaction of backfill. Testing for pipes greater than 24-inch in diameter shall be tested prior to the installation of drainage structure cone and frame.

D. Installed pipe shall be tested to ensure that the maximum deflection of the pipe does not exceed 7.5 percent of its base inside diameter. The base inside diameter is defined as the specified nominal diameter minus the allowable inside diameter tolerance of 1.5% but not more than 1/2 inch.

E. A mandrel shall be pulled through the pipe by hand to ensure that maximum allowable deflections have not been exceeded. The mandrel diameter shall be verified and approved by the Owner’s Representative prior to use. Use of an unapproved mandrel will invalidate the test. If the mandrel fails to pass through the pipe, the pipe will be deemed to be over-deflected.

F. The mandrel shall be a rigid device, with an odd number of legs (9 legs minimum) having an effective length not less than its nominal diameter. The mandrel shall be fabricated of steel with pulling rings at each end.

G. The minimum diameters at any point along the full length are as follows:

Nominal Size	Minimum Mandrel Diameter
6”	5.3”
8”	7.0”
10”	8.8”
12”	10.6”
15”	13.2”
18”	15.8”
24”	21.1”
30”	26.4”
36”	31.7”
42”	37.0”
48”	42.2”
54”	47.5”
60”	52.8”

3.21 FIELD QUALITY CONTROL

A. Testing: Perform testing of completed piping in accordance with the City of Worcester.

B. Video Inspections: Seven days after the completion of the backfilling of each section of new pipe, as defined as a length of pipe between two manholes, the Contractor will provide a televised inspection of the pipe to be submitted to the Designer. The Owner’s Representative shall be present during the recording. The recording shall be in DVD color format with audio and will show a clear picture of the inside of the new pipe. If the Designer determines that the DVD is unacceptable for review the contractor shall re-televise the line until an acceptable DVD has been submitted. In the event that the pipe is not acceptable for any reason relating to the proper construction of the pipe according to these specifications, the Contractor will be responsible to re-excavate and repair the defects to the satisfaction of the Designer at no additional cost.

C. Cleaning: Clear interior of piping and structures of dirt and other superfluous material as work progresses. Maintain swab or drag in piping and pull past each joint as it is completed.

1. In large, accessible piping, brushes and brooms may be used for cleaning.
2. Place watertight plugs in ends of uncompleted pipe at end of day or whenever work stops. If water is in the trench when work is resumed, the plug shall not be removed until the trench has been dewatered and all danger of water entering the pipe eliminated.
3. Flush piping between manholes to remove collected debris.

D. Interior Inspection: If deemed necessary by the Owner’s Representative, inspect piping to determine whether line displacement or other damage has occurred.

1. Make inspections after pipe between manholes has been installed and approximately 2 feet of backfill is in place, and again at completion of project.
2. If inspection indicates poor alignment, debris, displaced pipe, infiltration or other defects, the Contractor shall correct such defects and reinspect.

E. Prior to acceptance of the storm drainage system, the Contractor shall submit the following to the Architect and to the local authority:

1. System As-Built Plan stamped by a Professional Land Surveyor or Engineer Registered in the Commonwealth of Massachusetts.
2. Video inspection DVDs and report: The report shall document the observations of the video inspections.
3. Deflection test report: The report shall fully describe the test procedures and list the test results. The report shall be signed by the Contractor's superintendent.

3.22 FINAL INSPECTION

A. Final inspection and acceptance of the storm drainage system shall be made by the Owner's Representative and the utility owner having jurisdiction of the particular system.

B. Prior to placing the systems in service, all components shall be inspected, with the Owner's Representative present, to ensure that no debris or other contaminants are present. If necessary, the Contractor shall clean the structures and flush piping.

C. The Contractor is responsible for coordinating and scheduling the inspection of the work by local jurisdictional authorities. No additional payment will be made for inspections and permits required in the performance of the work.

End of Section