Project Manual – Volume 2
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Kirby School District 140
New Fernway Park Elementary School
16600 South 88th Avenue, Orland Park, Illinois 60462

For

The Board of Education
Kirby School District 140
Administrative Center
16931 S. Grissom Drive
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SECTION 15010

BASIC MECHANICAL REQUIREMENTS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this and the other sections of Division 15 and Division 17.

1.2 SUMMARY

A. This Section includes general administrative and procedural requirements for mechanical installations. The following administrative and procedural requirements are included in this Section to expand the requirements specified in Division 1:
   1. Submittals.
   2. Coordination drawings.
   3. Record documents.
   4. Maintenance manuals.
   5. Rough-ins.
   6. Mechanical installations.
   7. Cutting and patching.

1.3 DEFINITIONS

A. Furnish: To purchase; fabricate, as applicable; and deliver to designated location on job site.
B. Install: To locate and make all necessary connections for complete and operating system. Installing contractor shall provide all necessary labor and miscellaneous piping, fittings, connectors, ductwork, etc. as required for installation and startup. Installing contractor shall also be responsible for all warranties, including the coordination and implementation of all factory warranties, regardless of whether or not the installing contractor has furnished the equipment.
C. Provide: To furnish and install.

1.4 CODES AND STANDARDS

A. Code Compliance: Comply with all applicable codes pertaining to product materials and installations.
B. All product materials and work shall comply to all local codes, including but not limited to the following codes and standards as applicable, in addition to any codes and standards referenced within individual specification sections. These codes and standards shall apply to all Division 15 Sections as applicable.
   1. Americans with Disabilities Act (ADA)
   2. American Gas Association (AGA)
   3. American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE)
   4. American Society of Mechanical Engineers (ASME)
   5. Air Moving and Conditioning Associates (AMCA)
   6. American Society for Testing and Materials (ASTM)
   7. American Society of Plumbing Engineers (ASPE)
   8. American National Standard Institute (ANSI)
   9. Air Conditioning and Refrigeration Institute (ARI)
   10. International Building Code 2015.
   11. International Mechanical Code 2015.
   12. Factory Mutual
   13. Illinois Administrative Code, including, but not limited to:
      a. Illinois State Plumbing Code
      b. Illinois Accessibility Code
   14. National Electric Code (NEC)
   15. National Electric Manufacturers' Association (NEMA)
   16. All applicable sections of National Fire Protection Association (NFPA) 2014.
   17. Underwriters' Laboratories (UL)
   18. Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)

1.5 SUBMITTALS

A. General: Follow the procedures specified in Division 1 Sections, and additional defined below.
B. Increase by one copy the number of mechanical related shop drawings, product data, and samples submitted, as required, and defined in Division 2, to allow for required distribution. This copy will be retained by the Consulting Engineer.
C. Additional copies may be required by individual sections of these Specifications.
D. Highlight, encircle, or otherwise indicate deviations from the Contract Documents. Deviations included within shop drawings shall not be acceptable unless they are clearly identified as deviations. Deviations from the Contract Documents shall only be acceptable subsequent to the deviation being specifically submitted in writing and responded to by the architect and engineer.

1.6 COORDINATION DRAWINGS

A. Each trade shall prepare original coordination drawings in accordance with Division 1 Sections, other Division 15, 16 and 17 Sections and as additionally defined below. Provide individual drawings for each trade, including (1) reproducible copy. Provide original drawings meeting the requirements as described in this section. Marked up copies of the design documents are not acceptable.
B. Drawings shall include the latest architectural floor plan with column lines identified. These drawings shall detail all elements, components, and systems of the applicable mechanical, plumbing, or fire protection trade. Drawings shall also indicate the locations of other trades and indicate their relationship in all areas where limited space requires detailed coordination. All system components of trade being presented shall appear dark and be easily distinguished from architectural information or other system information included for coordination purposes. All information included that is not a part of the system being presented shall be indicated light or half tone. Indicate locations where space is limited for installation and access and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:
    1. Indicate the proposed locations of piping, ductwork, equipment, and materials. Include the following:
        a. Ductwork mains and branches, size and location, for both exterior and interior; locations of dampers and other control devices; filters, boxes, and terminal units requiring periodic maintenance or repair.
        b. Mains and branches of all piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located (i.e., air separators, strainers, expansion compensators, tanks, etc.). Indicate actual inverts and horizontal locations of underground piping.
        c. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
        d. Clearances for installing and maintaining insulation.
        e. Clearances for servicing and maintaining equipment, including tube removal, filter removal, and space for equipment disassembly required for periodic maintenance.
        f. Equipment connections and support details.
        g. Exterior wall and foundation penetrations.
        h. Fire-rated wall and floor penetrations.
        i. Sizes and location of required concrete pads and bases.
        j. Valve stem movement.
        k. Indicate location of all equipment, ductwork, plumbing fixtures, piping etc., with dimensions from prominent building lines; and elevations above corresponding floors, roofs or grade as applicable.
    2. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.
    3. Prepare floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.

4. Prepare reflected ceiling plans to coordinate and integrate installations, air outlets and inlets, light fixtures, communication systems components, sprinklers, and other ceiling-mounted items. Dimension all items from prominent building lines except for those located in modular type ceilings.
5. Submit all coordination drawings and/or shop drawings prior to purchase, fabrication, or installation of any equipment. Any work started or equipment purchased prior to the review of submitted drawings by the design engineer is done at the contractor's risk. The offending contractor shall be entirely responsible for all changes, modifications, and/or extra services required resulting from the improper coordination and/or improper submittal procedures.
6. Encircle or bubble any revisions made on drawings being submitted more than one time. Indicate all revisions or changes made subsequent to the previous submittal reviewed by the engineer.

C. Electronic backgrounds (plan sheets only) are available from the office of the Consulting Engineer for a flat fee of $250.00 per trade (i.e.: mechanical, plumbing, electrical, fire protection). Contractor will be required to sign a waiver of release of the documents prior to electronic transmittal.
D. See front end documents for additional coordination requirements.

1.7 RECORD DOCUMENTS

A. Prepare record documents in accordance with the requirements in Division 1 Sections and other Division 15 Sections. In addition to the requirements specified in Division 1, indicate the following installed conditions:
   1. Provide one (1) digital copy (CD) and one (1) full size paper copy of “as-built” drawings with all information and meeting the requirements as described under “Coordination Drawings” in this section. MARKED UP COPIES OF THE DESIGN DOCUMENTS ARE NOT ACCEPTABLE.
   2. Approved substitutions, Contract Modifications, and actual equipment and materials installed.
   3. The as-built drawings shall indicate the electrical installations as “installed” and required as described under “Coordination Drawings” and “Record Drawings”.
   4. As-Built drawings shall be complete on contractors own “Title Block”.

1.8 MAINTENANCE MANUALS

A. Prepare maintenance manuals in accordance with Division 1 Sections. In addition to the requirements specified in Division 1, include the following information for equipment items:
   1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
   2. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
   3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
   4. Servicing instructions and lubrication charts and schedules.

1.9 WARRANTIES

A. The Contractor shall warrant all Mechanical Work to be free of faults and defects in accordance with the General Conditions and Supplementary Conditions for a minimum period of one (1) year from final acceptance of the work. This shall include all materials and labor. Extended warranties shall be provided as indicated in other sections of these Specifications.
B. The Contractor shall submit signed warranties for installations, equipment and fixtures required by this section and other sections of these Specifications.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for identification.
B. Store and protect products under provisions of Division 1 General Requirements.
C. Deliver and store material in shipping containers with labeling in place.
D. Contractor shall store all materials shipped to this site in a protected area. If material is stored outside of the building, it must be stored off the ground a minimum of six inches set on 6 x 6 planks and/or wood pallets. All material must be completely covered with waterproof tarps or visqueen. All piping will have the ends closed to keep out dirt and other debris. No equipment will be allowed to be stored on the site unless it is sitting on wood planks and is completely protected with weatherproof covers.

PART 2 – PRODUCTS

(Not Applicable)

PART 3 – EXECUTION

3.1 ROUGH-IN

A. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.
B. Refer to equipment specifications in Divisions 2 through 17 for additional rough-in requirements.

3.2 MECHANICAL INSTALLATIONS

A. General: Sequence, coordinate, and integrate the various elements of mechanical systems, materials, and equipment. Comply with the following requirements:
   1. Coordinate mechanical systems, equipment, and materials installation with other building components.
   2. Verify all dimensions by field measurements.
   3. Confirm and arrange for chases, slots, and openings in other building components during progress of construction, to allow for mechanical installations.
   4. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.
   5. Sequence, coordinate, and integrate installations of mechanical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.
   6. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.
   7. Coordinate connection of mechanical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.
   8. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Architect.
   9. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components.

10. Install mechanical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as practical, connect equipment for ease of disconnecting, with minimum of interference with other installations. Extend grease fittings to an accessible location and purge all extended hoses with grease. Use extreme pressure grease to match District standards.
11. Install access panel or doors where units are concealed behind finished surfaces. Access panels and doors are specified in Division 15 Section - Ductwork Accessories.
12. Indicate locations and sizes for all access panels or doors where required for service of mechanical devices. Provide this information to the mason and/or drywall contractor before construction of corresponding partition.
13. Access doors shall be required for service of any concealed device such as fire dampers, valves, fans, controls, and coils. As much as practical, locate these devices in readily accessible locations.
14. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.
15. General Locations and Arrangements: Drawings (plans, schematics, and diagrams) indicate the general location and arrangement of the systems in a diagrammatic form only. Location and arrangement of pipe, duct, and equipment lay-out shall take into consideration pipe/duct sizing and pressure loss, expansion, pump/fan sizing, and other design considerations. So far as practical, install system as indicated. Refer to individual system specifications for requirements for coordination drawing submittals. Adjust routing and provide all offsets, fittings, etc., as required for coordination with building and all other systems at no additional cost to the owner. All deviations from the design drawings shall be reflected on the shop drawings for review by the architect and engineer before proceeding with fabrication or installation.
16. Where drawings, specifications or notes conflict one another the contractor shall immediately advise the architect of such conflicts. For purposes of bidding and pending written receipt of any direction to the contrary, the contractor shall include in his proposal the more expensive alternate described.

3.3 CUTTING AND PATCHING

A. General: Perform cutting and patching in accordance with Division 1 Sections. In addition to the requirements specified in Division 1, the following requirements apply:
   1. Protection of Installed Work: During cutting and patching operations, protect adjacent installations.
B. Perform cutting, fitting, and patching of mechanical equipment and materials required to:
   1. Uncover Work to provide for installation of ill-timed Work.
   2. Remove and replace defective Work.
   3. Remove and replace Work not conforming to requirements of the Contract Documents.
   4. Remove samples of installed Work as specified for testing.
   5. Upon written instructions from the Architect, uncover and restore Work to provide for Architect/Engineer observation of concealed Work.
C. Provide and maintain temporary partitions or dust barriers adequate to prevent the spread of dust and dirt to adjacent areas.
   1. Patch finished surfaces and building components using new materials specified for the original installation and experienced Installers. Installers' qualifications refer to the materials and methods required for the surface and building components being patched.
D. All piping penetrations to be by contractor including sleeves and patching. Use coring whenever possible through concrete and masonry.
E. Contractor to fire safe and seal all wall penetrations for ductwork, piping, conduits, etc. in new and existing walls or floors.

END OF SECTION

SECTION 15121

PIPING EXPANSION COMPENSATION

PART 1 – GENERAL

1.1 WORK INCLUDED
A. Flexible pipe connectors.
B. Pipe loops, offsets and swing joints.
C. Steel and copper pipe guides and anchors.

1.2 RELATED SECTIONS
A. Section 15140 - Supports and Anchors.
B. Section 15410 - Plumbing Piping.
C. Section 15510 - Hydronic Piping.
D. Section 15515 - Hydronic Specialties.
E. Section 15545 - Chemical Water Treatment.

1.3 REFERENCES
A. Conform to Standards of Expansion Joint Manufacturers Association Selection Guide.
B. ASHRAE Chapter 23, Pipes Tubes and Fittings.

1.4 PERFORMANCE REQUIREMENTS
A. Provide structural work and equipment required to control expansion and contraction of piping. Verify that anchors, guides, and expansion joints provided, adequately protect system.
B. Expansion Calculations:
   1. Installation Temperature: 40 degrees F.
   2. Chilled water: 40 degrees.
   3. Hot Water Heating and Condensate: 210 degrees F.
   4. Domestic Hot Water: 140 degrees F.
   5. Safety Factor: 30 percent.

1.5 SUBMITTALS
A. Submit under provisions of Division 1 General Requirements.
B. Product Data:
   1. Flexible Pipe Connectors: Indicate maximum temperature and pressure rating, face to face length, live length, hose wall thickness, hose convolutions per foot (meter) and per assembly, fundamental frequency of assembly, braid structure, and total number of wires in braid.
   2. Expansion Joints: Indicate maximum temperature and pressure rating, and maximum expansion compensation.
C. Design Data: Indicate selection calculations.
D. Manufacturer's Installation Instructions: Indicate special procedures, and external controls.

1.6 PROJECT RECORD DOCUMENTS
A. Submit under provisions of Division 1 General Requirements.
B. Record actual locations of flexible pipe connectors, expansion joints, anchors, and guides.

1.7 OPERATION AND MAINTENANCE DATA
A. Submit under provisions of Division 1 General Requirements.
B. Maintenance Data: Include adjustment instructions.

1.8 QUALIFICATIONS
A. Manufacturer: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

1.9 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site under provisions of Division 1 General Requirements.
B. Accept expansion joints on site in factory packing with shipping bars and positioning devices intact. Inspect for damage.
C. Protect equipment from exposure by leaving factory coverings, pipe end protection, and packaging in place until installation.

1.10 WARRANTY

A. Contractor shall provide a one (1) year manufacturer's warranty on parts on furnished equipment. Equipment parts warranty shall start at time of substantial completion. Contractor will provide a one (1) year warranty on all labor associated with the equipment and its' installation. Warranty shall start at date of final payment. See General Requirements for additional requirements.
B. Warranty: Include coverage for leak free performance of packed expansion joints.

PART 2 – PRODUCTS

2.1 FLEXIBLE PIPE CONNECTORS

A. Manufacturers:
   1. Mason Industries - Model BSS.
   2. MetraFlex - Model Mini.
   3. Hyspan Precision - Model 4500.
   4. General Rubber Corporation.
   5. Victaulic Engineered Assemblies.
B. Inner Hose: Stainless Steel.
C. Exterior Sleeve: Double braided, bronze.
D. Pressure Rating: 200 psi WOG and 250 degrees F maximum temperature.
E. Joint: Flanged.
F. Maximum offset: 1 inch on each side of installed center line.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.
B. Construct spool pieces to exact size of flexible connection for future insertion.
C. Install flexible pipe connectors on pipes connected to equipment supported by vibration isolation. Provide line size flexible connectors.
D. Install flexible connectors at right angles to displacement. Install one end immediately adjacent to isolated equipment and anchor other end. Install in horizontal plane unless indicated otherwise.
E. Provide support and equipment required to control expansion and contraction of piping. Provide loops, pipe offsets or expansion joints where required.
F. Provide expansion loops as required on drawings or as required by field conditions. Engineered expansion compensators shall be used in lieu of expansion loops if clearance is limited.
G. Rigidly anchor pipe to building structure where necessary.

END OF SECTION

SECTION 15135

GAGES AND METERS

PART 1 – GENERAL

1.1 WORK INCLUDED
A. Pressure gages and Pressure gage taps.
B. Thermometers and thermometer wells.
C. Filter gages.

1.2 RELATED SECTIONS
A. Section 15410 - Plumbing Piping.
B. Section 15510 - Hydronic Piping: Installation of Thermometer wells, pressure gage tappings.
C. Section 15545 - Chemical Water Treatment.
D. Section 15558 – Condensing Firetube Boiler.
E. Section 15790 - Air Coils.
F. Section 15836 – Terminal Heat Transfer Units.
G. Section 15838 – Vertical Unit Ventilators.
H. Section 15855 – Air Handling Units.
I. Division 17 - Building Automation System.

1.3 REFERENCES
A. ASME - B40.1 - Gages - Pressure Indicating Dial Type - Elastic Element.
B. ASTM E1 - Specification for ASTM Thermometers.
C. ASTM E77 - Verification and Calibration of Liquid in Glass Thermometers.
D. AWWA C700 - Cold Water Meters - Displacement Type.
E. UL 393 - Indicating Pressure Gages for Fire and Protection Services.

1.4 SUBMITTALS FOR REVIEW
A. Product Data: Provide list, which indicates use, operating range, total range and location for manufactured components.
B. Submit under provisions of Division 1 General Requirements.

1.5 SUBMITTALS AT PROJECT CLOSEOUT
A. Project Record Documents: Record actual locations of components and instrumentation.
B. Submit under provision of Division 1 General Requirements.

1.6 INSTALLATION OF DIVISION 17 PRODUCTS
A. Install valves, temperature and pressure sensors and other instrumentation in the locations directed by the BAS contractor.
B. Install BAS valves and sensors in the locations shown on the plans.
C. Failure of this contractor to adequately coordinate his work with the BAS contractor shall not be justification for any request for additional payment.
D. This contractor shall include the cost of coordinating and installing related BAS components in his bid.

PART 2 – PRODUCTS

2.1 PRESSURE GAGES
A. Manufacturers:
   1. Terice.
   2. No Substitutions.
B. Gage: ASME B40.1, stainless steel or cast aluminum case, phosphor bronze bourdon tube, rotary brass movement, brass socket, with adjustable pointer, black scale on white background.
   1. Case: Stainless steel or cast aluminum with brass bourdon tube.
   2. Size: 4½-inch diameter (minimum).
   3. Mid-Scale Accuracy: One percent full scale.
   4. Scale: Psi.

2.2 PRESSURE GAGE TAPPINGS

A. Gage Cock: Tee or lever handle, brass for maximum 150 psig.
B. Needle Valve: Brass, ¼-inch NPT for minimum 150 psig.
C. Pulsation Damper: Pressure snubber, brass with ¼-inch connections.
D. Syphon: Steel, Schedule 40, ¼-inch angle or straight pattern.

2.3 STEM TYPE THERMOMETERS

A. Manufacturers:
   1. Miljoco.
   2. Weiss.
B. Thermometer: ASTM E1, adjustable angle, blue organic, lens front tube, cast aluminum case with enamel finish, cast aluminum adjustable joint with positive locking device.
   1. Size: 9-inch scale.
   2. Window: Clear Lexan.
   3. Stem: ¾ inch NPT brass.
   4. Accuracy: One scale division.
   5. Calibration: Degrees F.

2.4 THERMOMETER SUPPORTS

A. Socket: Brass separable sockets for thermometer stems with or without extensions as required, and with cap and chain.
B. Flange: 3-inch outside diameter reversible flange, designed to fasten to sheet metal air ducts, with brass perforated stem.

2.5 TEST PLUGS

A. Test Plug: ¼-inch or 2-inch brass fitting and cap for receiving 1/8-inch outside diameter pressure or temperature probe with neoprene core for temperatures up to 210-degrees F.
B. Test Kit: Carrying case, internally padded and fitted containing one 2½-inch diameter pressure gages, one gage adapters with 1/8-inch probes, two one-inch dial thermometers.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.
B. Install pressure gages with pulsation dampers. Provide gage cock to isolate each gage.
C. Install thermometers in piping systems in sockets in short couplings. Enlarge pipes smaller than 2 1/2 inch for installation of thermometer sockets. Ensure sockets allow clearance from insulation.
D. Install thermometer sockets and pressure taps as directed by BAS contractor adjacent to controls systems transmitter, or sensor sockets and as required in Division 17.
E. Coil and conceal excess capillary on remote element instruments.
F. Provide instruments with scale ranges selected according to service with largest appropriate scale.
G. Install gages and thermometers in locations where they are easily read from normal operating level. Install vertical to 45 degrees off vertical.
H. Adjust gages and thermometers to final angle, clean windows and lenses, and calibrate to zero.
I. Locate test plugs adjacent thermometers and thermometer sockets and adjacent to pressure gages and pressure gage taps.
J. Install all gauges and meters.

3.2 SCHEDULES

A. Pressure Gage Schedule
   LOCATION
   Pumps
   Pressure reducing valves
   Pressure Tanks
   Boiler – inlet and outlet
   Chiller – inlet and outlet

B. Pressure Gage Tapping Schedule
   LOCATION
   Pumps
   Major coils - inlets and outlets
   Control pressure-sensing locations
   Boiler – inlet and outlet
   Chiller – inlet and outlet

C. Stem Type Thermometer Schedule
   LOCATION
   Headers to central equipment
   Coil banks - inlets and outlets
   After major coils
   Blower coils – inlet and outlet
   Boilers – inlets and outlets
   Water zone supply and return
   Domestic hot water supply and recirculation
   New and existing air handling unit coils – inlet and outlet
   Chiller – inlet and outlet

D. Thermometer Socket Schedule
   LOCATION
   Control temperature-sensing locations
   Heating and cooling coils – inlet and outlet
   Cabinet and Suspended unit heaters – inlet and outlet

E. Static Pressure and Filter Gage Schedule
   LOCATION
   Unitary filter sections
   Air handling unit filter sections
   Duct locations for VFD fan control

END OF SECTION

SECTION 15140

SUPPORTS AND ANCHORS

PART 1 – GENERAL

1.1 WORK INCLUDED

A. Pipe and equipment hangers and supports.
B. Inserts.
C. Equipment bases and supports.
D. Sleeves and seals.
E. Flashing and sealing equipment and pipe stacks.

1.2 RELATED SECTIONS

A. Section 15242 - Vibration Isolation.
B. Section 15260 - Piping Insulation.
C. Section 15410 - Plumbing Piping.
D. Section 15505 - Fuel Piping.
E. Section 15510 - Hydronic Piping.
F. Section 15870 - Power Ventilators.

1.3 REFERENCES

A. American Society of Mechanical Engineers:
   1. ASME B31.1 – Power Piping.
   2. ASME B31.2 – Fuel Gas Piping.
   3. ASME B31.9 – Building Services Piping.
B. ASTM International:
   1. ASTM E119 – Standard Test Methods for Fire Tests of Building Construction and Materials.
   2. ASTM E814 – Standard Test Method for Fire Tests of Through Penetration Fire Stops.
   3. ASTM F708 – Standard Practice for Design and Installation of Rigid Pipe Hangers.
   4. ASTM E1966 – Standard Test Method for Fire-Resistive Joint Systems.
C. American Welding Society:
   1. AWS D1.1 – Structural Welding Code – Steel.
D. FM Global:
   1. FM – Approved Guide, A Guide to Equipment, Materials & Services Approved by Factory Mutual Research for Property Conservation.
E. Underwriters Laboratories, Inc.
   1. UL 263 – Fire Tests of Building Construction and Materials.
   2. UL 723 – Tests for Surface Building Characteristics of Building Materials.
   3. UL 1479 – Fire Tests of Through-Penetration Firestops.
   4. UL 2079 – Tests for Fire Resistance of Building Joint Systems.
   5. UL – Fire Resistance Directory.

1.4 DEFINITIONS

A. Firestopping (Through-Penetration Protection System): Sealing or stuffing material or assembly placed in spaces between and penetrations through building materials to arrest movement of fire, smoke, heat, and hot gases through fire rated construction.

1.5 SUBMITTALS

A. Submit under provisions of Division 1 General Requirements.
B. Shop Drawings: Indicate system layout with location and detail of trapeze hangers.
C. Product Data: Provide manufacturers catalog data including load capacity.
D. Design Data: Indicate load carrying capacity of trapeze, multiple pipe, and riser support hangers.
E. Manufacturer's Installation Instructions: Indicate special procedures and assembly of components.

1.6 REGULATORY REQUIREMENTS

A. Conform to 2015 International Mechanical Code for support of plumbing or hydronic piping.

PART 2 – PRODUCTS

2.1 PIPE HANGERS AND SUPPORTS

A. Plumbing Piping - DWV:
   1. Conform to ASME B31.9, ASTM F708.
   2. Hangers for Pipe Sizes 2 to 1½-inch: Malleable iron, adjustable swivel, split ring.
   3. Hangers for Pipe Sizes 2 -inches and Over: Carbon steel, adjustable, clevis.
   4. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
   5. Wall Support for Pipe Sizes to 3-inches: Cast iron hook.
   6. Wall Support for Pipe Sizes 4-inches and Over: Welded steel bracket and wrought steel clamp.
   7. Vertical Support: Steel riser clamp.
   8. Floor Support: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
   9. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.

B. Plumbing Piping - Water:
   1. Conform to ASME B31.9, ASTM F708.
   2. Hangers for Pipe Sizes 2 to 1½-inch: Malleable iron, adjustable swivel, split ring.
   3. Hangers for Cold Pipe Sizes 2-inches and Over: Carbon steel, adjustable, clevis.
   4. Hangers for Hot Pipe Sizes 2 to 4-inches: Carbon steel, adjustable, clevis.
   5. Hangers for Hot Pipe Sizes 6-inches and Over: Adjustable steel yoke, cast iron roll, double hanger.
   6. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
   7. Multiple or Trapeze Hangers for Hot Pipe Sizes 6-inches and Over: Steel channels with welded spacers and hanger rods, cast iron roll.
   8. Wall Support for Pipe Sizes to 3-inches: Cast iron hook.
   9. Wall Support for Pipe Sizes 4-inches and Over: Welded steel bracket and wrought steel clamp.
   10. Vertical Support: Steel riser clamp.
   11. Floor Support for Cold Pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
   12. Floor Support for Hot Pipe Sizes to 4-inches: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
   13. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.

C. Hydronic Piping:
   1. Conform to ASME B31.9, ASTM F708.
   2. Hangers for Pipe Sizes ½ to 1½-inch: Malleable iron, adjustable swivel, split ring.
   3. Hangers for Hot Pipe Sizes 2 to 4-inches: Carbon steel, adjustable, clevis.
   4. Hangers for Hot Pipe Sizes 6 -inches and Over: Adjustable steel yoke, cast iron roll, double hanger.
   5. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
   6. Multiple or Trapeze Hangers for Hot Pipe Sizes 6-inches and Over: Steel channels with welded spacers and hanger rods, cast iron roll.
   7. Wall Support for Pipe Sizes to 3-inches: Cast iron hook.
   8. Wall Support for Pipe Sizes 4-inches and Over: Welded steel bracket and wrought steel clamp.
   9. Wall Support for Hot Pipe Sizes 6-inches and Over: Welded steel bracket and wrought steel clamp with adjustable steel yoke and cast-iron roll.
   10. Vertical Support: Steel riser clamp.
   11. Floor Support for Hot Pipe Sizes to 4-inches: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
   12. Floor Support for Hot Pipe Sizes 6-inches and Over: Adjustable cast iron roll and stand, steel screws, and concrete pier or steel support.
   13. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.

D. Fuel Gas Piping:
   1. Conform to ASME B31.2, ASTM F708.
   2. Hangers for Pipe Sizes 2 to 1½-inch: Malleable iron, adjustable swivel, split ring.
   3. Hangers for Hot Pipe Sizes 2 to 4-inches: Carbon steel, adjustable, clevis.
   4. Hangers for Hot Pipe Sizes 6 -inches and Over: Adjustable steel yoke, cast iron roll, double hanger.
   5. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
   6. Multiple or Trapeze Hangers for Hot Pipe Sizes 6-inches and Over: Steel channels with welded spacers and hanger rods, cast iron roll.
   7. Wall Support for Pipe Sizes to 3-inches: Cast iron hook.
   8. Wall Support for Pipe Sizes 4-inches and Over: Welded steel bracket and wrought steel clamp.
   9. Vertical Support: Steel riser clamp.
   10. Floor Support for Hot Pipe Sizes to 4-inches: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
   11. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.

E. Refrigerant Piping:
   1. Conform to ASME B31.5, ASTM F708.
   2. Hangers for Pipe Sizes to 1½-inch: Malleable iron, adjustable swivel, split ring.
   3. Hangers for Pipe Sizes 2-inches and Over: Carbon steel, adjustable, clevis.
   4. Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods.
   5. Wall Support for Pipe Sizes to 3-inches: Cast iron hook.
   6. Vertical Support: Steel riser clamp.
   7. Floor Support: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
   8. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.

2.2 ACCESSORIES

A. Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded.

2.3 INSERTS

A. Inserts: Malleable iron case of galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms; size inserts to suit threaded hanger rods.

2.4 FLASHING

A. Metal Flashing: 26-gauge stainless steel.
B. Metal Counterflashing: 22-gauge stainless steel.
C. Lead Flashing:
   1. Waterproofing: 5 lb./sq. ft. sheet lead.
   2. Soundproofing: 1 lb./sq. ft. sheet lead.
D. Flexible Flashing: 47 mil thick sheet compatible with roofing.
E. Caps: Stainless steel, 22-gauge minimum; 16-gauge at fire resistant elements.

2.5 EQUIPMENT CURBS

A. Manufacturers:
   1. Thycurb.
   2. Pate.
   3. Approved Equal.
B. Fabrication: Welded 18-gauge stainless steel or aluminum shell and base, mitered 3-inch cant, 1½-inch thick insulation, factory installed wood nailer, 18-inches high, see architectural drawings for additional information.

2.6 SLEEVES

A. Sleeves for Pipes through Non-Fire Rated Floors: 18-gauge galvanized steel.
B. Sleeves for Pipes through Non-Fire Rated Beams, Walls, Footings, and Potentially Wet Floors: Steel pipe or 18-gauge galvanized steel.
C. Sleeves for Pipes through Fire Rated and Fire Resistive Floors and Walls, and Fire Proofing: Prefabricated fire rated sleeves including seals, UL listed.
D. Sleeves for Round Ductwork: Galvanized steel.
E. Sleeves for Rectangular Ductwork: Galvanized steel.
F. Firestopping Insulation: Glass fiber type, non-combustible.
G. Sealant: Acrylic.

2.7 MECHANICAL SLEEVE SEALS

A. Product Description: Modular mechanical type, consisting of interlocking synthetic rubber links shaped to continuously fill annular space between object and sleeve, connected with bolts and pressure plates causing rubber sealing elements to expand when tightened, providing watertight seal and electrical insulation.

2.8 FORMED STEEL CHANNEL

A. Product Description: Galvanized 12-gauge thick steel. With holes 1½-inches on center.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

3.2 INSERTS

A. Provide inserts for placement in concrete formwork.
B. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
C. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4-inches.
D. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.

3.3 PIPE HANGERS AND SUPPORTS

A. Support horizontal piping as scheduled.
B. Install hangers to provide minimum 2-inch space between finished covering and adjacent work.
C. Place hangers within 12-inches of each horizontal elbow.
D. Use hangers with 1½-inch minimum vertical adjustment.
E. Support horizontal cast iron pipe adjacent to each hub, with 5 feet maximum spacing between hangers.
F. Support vertical piping at every floor. Support vertical cast iron pipe at each floor at hub.
G. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
H. Support riser piping independently of connected horizontal piping.
I. Provide copper plated hangers and supports for copper piping.
J. Design hangers for pipe movement without disengagement of supported pipe.

3.4 EQUIPMENT BASES AND SUPPORTS

A. Provide housekeeping pads of concrete, minimum 6 -inches thick and extending 6 -inches beyond supported equipment.
B. Provide templates, anchor bolts, and accessories for mounting and anchoring equipment.
C. Construct supports of steel members. Brace and fasten with flanges bolted to structure.
D. Provide rigid anchors for pipes after vibration isolation components are installed.

3.5 FLASHING

A. Provide flexible flashing and metal counterflashing where piping and ductwork penetrate weather or waterproofed walls, floors, and roofs.
B. Flash vent and soil pipes projecting 3-inches minimum above finished roof surface with lead worked one -inch minimum into hub, 8-inches minimum clear on sides with 24 x 24-inches sheet size. For pipes through outside walls, turn flanges back into wall and calk, metal counter flash, and seal.
C. Flash floor drains in floors with topping over finished areas with lead, 10 -inches clear on sides with minimum 36 x 36-inch sheet size. Fasten flashing to drain clamp device.
D. Seal floor, shower and mop sink drains watertight to adjacent materials.
E. Provide curbs for mechanical roof installations 18-inches minimum high above roofing surface. Flash and counter flash with sheet metal; seal watertight. Attach counterflashing mechanical equipment and lap base flashing on roof curbs. Flatten and solder joints. Roof curbs shall match roof pitch.
F. Adjust storm collars tight to pipe with bolts; caulk around top edge. Use storm collars above roof jacks. Screw vertical flange section to face of curb.

3.6 SLEEVES

A. Set sleeves in position in wall.
B. Size sleeves large enough to allow for movement due to expansion and contraction. Provide for continuous insulation wrapping.
C. Where piping or ductwork penetrates floor, ceiling, or wall, close off space between pipe or duct and adjacent work with fire stopping insulation and calk air tight. Provide close fitting metal collar or escutcheon covers at both sides of penetration.
D. Install chrome plated steel escutcheons at finished surfaces.

3.7 SCHEDULES

A. Copper and Steel Pipe Hanger Spacing:

PIPE SIZE - inches	COPPER TUBING MAXIMUM HANGER SPACING Feet	STEEL PIPE MAXIMUM HANGER SPACING Feet	COPPER TUBING HANGER ROD DIAMETER - inches	STEEL PIPE HANGER ROD DIAMETER - inches
1/2	5	7	3/8	3/8
3/4	5	7	3/8	3/8
1	6	7	3/8	3/8
1-1/4	7	7	3/8	3/8
1-1/2	8	9	3/8	3/8
2	8	10	3/8	3/8
2-1/2 (Note 2)	9	11	1/2	1/2
3	10	12	1/2	1/2
4	12	14	1/2	5/8
5	13	16	1/2	5/8
6	14	17	5/8	3/4
8	16	19	3/4	3/4

B. Plastic and Ductile Iron Pipe Hanger Spacing:

PIPE MATERIAL	MAXIMUM HANGER SPACING Feet	HANGER ROD DIAMETER -inches
ABS (All sizes)	4	3/8
FRP (All Sizes)	4	3/8
Ductile Iron (Note 2)		
PVC (All Sizes)	4	3/8

C. Note 1: Refer to manufacturer's recommendations for grooved end piping systems.

D. Note 2: 20 feet maximum spacing, minimum of one hanger for each pipe section close to joint behind bell. Provide hanger at each change of direction and each branch connection. For pipe sizes 6 -inches and smaller, subjected to loadings other than weight of pipe and contents, limit span to maximum spacing for water service steel pipe.

END OF SECTION

SECTION 15170

MOTORS

PART 1 – GENERAL

1.1 WORK INCLUDED
A. Single phase electric motors.
B. Three phase electric motors.

1.2 REFERENCES
A. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings.
B. AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings.
C. IEEE 112 - Test Procedure for Polyphase Induction Motors and Generators.
D. NEMA MG 1 - Motors and Generators.
E. NFPA 70 - National Electrical Code.

1.3 SUBMITTALS
A. Submit under provisions of Division 1 General Requirements.
B. Product Data: Provide wiring diagrams with electrical characteristics and connection requirements.
C. Manufacturer's Installation Instructions: Indicate setting, mechanical connections, lubrication, and wiring instructions.

1.4 OPERATION AND MAINTENANCE DATA
A. Submit under provisions of Division 1 General Requirements.
B. Operation Data: Include instructions for safe operating procedures.
C. Maintenance Data: Include assembly drawings, bearing data including replacement sizes, and lubrication instructions.

1.5 QUALIFICATIONS
A. Manufacturer: Company specializing in manufacture of electric motors for commercial use, and their accessories, with minimum three (3) years documented product development, testing, and manufacturing experience.

1.6 REGULATORY REQUIREMENTS
A. Conform to NFPA 70 and ANSI.
B. Products Requiring Electrical Connection: Listed and classified by Underwriters' Laboratories, Inc., as suitable for the purpose specified and indicated.

1.7 DELIVERY, STORAGE, AND HANDLING
A. Deliver, store, protect and handle products to site under provisions of Division 1 General Requirements.
B. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weather proof covering.

1.8 WARRANTY
A. Provide five (5) year warranty under provisions of Division 1 General Requirements.
B. Warranty: Include coverage for motors larger than 5-horsepower.

PART 2 – PRODUCTS

2.1 MANUFACTURERS
A. Century E + 3 High Efficiency.
B. Lincoln.
C. Reliance.
D. Dayton.
E. General Electric.
F. No substitutions.

2.2 GENERAL CONSTRUCTION AND REQUIREMENTS

A. Motors Less Than 250 Watts, for Intermittent Service: Equipment manufacturer's standard and need not conform to these specifications.
B. Electrical Service:
   1. Motors ½-horsepower and Smaller: 208 or 120-volts, single-phase, 60 Hz.
   2. Motors Larger than ¾-Horsepower: 460-volts, three-phase, 60 Hz.
C. Type:
   1. Open drip proof except where specifically noted otherwise.
   2. Motors: Design for continuous operation in 40-degrees C environment.
   3. Design for temperature rise in accordance with NEMA MG 1 limits for insulation class, service factor, and motor enclosure type.
   4. Motors with frame sizes 184T and larger: Energy Efficient Type equal to Century E + 3.
D. Visible Nameplate: Indicating motor horsepower, voltage, phase, cycles, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, service factor, power factor, efficiency.
E. Wiring Terminations:
   1. Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70, threaded for conduit.
   2. For fractional horsepower motors where connection is made directly, provide threaded conduit connection in end frame.

2.3 SINGLE PHASE POWER - SPLIT PHASE MOTORS

A. Starting Torque: Less than 150 percent of full load torque.
B. Starting Current: Up to seven times full load current.
C. Breakdown Torque: Approximately 200 percent of full load torque.
D. Drip proof Enclosure: Class A insulation, NEMA Service Factor, pre-lubricated sleeve or ball bearings.
E. Enclosed Motors: Class A insulation, 1.0 Service Factor, pre-lubricated ball bearings.

2.4 SINGLE PHASE POWER - PERMANENT SPLIT CAPACITOR MOTORS

A. Starting Torque: Exceeding one fourth of full load torque.
B. Starting Current: Up to six times full load current.
C. Multiple Speed: Through tapped windings.
D. Open Drip proof or Enclosed Air Over Enclosure: Class A insulation, minimum 1.0 Service Factor, pre-lubricated sleeve or ball bearings, automatic reset overload protector.

2.5 SINGLE PHASE POWER - CAPACITOR START MOTORS

A. Starting Torque: Three times full load torque.
B. Starting Current: Less than five times full load current.
C. Pull up Torque: Up to 350 percent of full load torque.
D. Breakdown Torque: Approximately 250 percent of full load torque.
E. Motors: Capacitor in series with starting winding; provide capacitor start/capacitor run motors with two capacitors in parallel with run capacitor remaining in circuit at operating speeds.
F. Drip proof Enclosure: Class A insulation, NEMA Service Factor, pre-lubricated sleeve bearings.
G. Enclosed Motors: Class A insulation, 1.0 Service Factor, pre-lubricated ball bearings.

2.6 THREE-PHASE POWER - SQUIRREL CAGE MOTORS

A. Starting Torque: Between 1 and 1½ times full load torque.
B. Starting Current: Six times full load current.
C. Power Output, Locked Rotor Torque, Breakdown or Pull Out Torque: NEMA Design B characteristics.
D. Design, Construction, Testing, and Performance: Conform to NEMA MG 1 for Design B motors.
E. Insulation System: NEMA Class B or better.
F. Testing Procedure: In accordance with IEEE 112. Load test motors to determine free from electrical or mechanical defects in compliance with performance data.

G. Motor Frames: NEMA Standard T Frames of steel, aluminum, or cast iron with end brackets of cast iron or aluminum with steel inserts.
H. Thermistor System Motor Frame Sizes 254T and Larger: Three PTC thermistors imbedded in motor windings and epoxy encapsulated solid state control relay for wiring into motor starter.
I. Bearings: Grease lubricated anti friction ball bearings with housings equipped with plugged provision for relubrication, rated for minimum AFBMA 9, L 10 life of 20,000 hours. Calculate bearing load with NEMA minimum V belt pulley with belt center line at end of NEMA standard shaft extension. Stamp bearing sizes on nameplate. Replace plugs at completion of project and provide grease fittings.
J. Sound Power Levels: To NEMA MG 1.
K. Part Winding Start Above 254T Frame Size: Use part of winding to reduce locked rotor starting current to approximately 60 percent of full winding locked rotor current while providing approximately 50 percent of full winding locked rotor torque.
L. Weatherproof Epoxy Sealed Motors: Epoxy seal windings using vacuum and pressure with rotor and starter surfaces protected with epoxy enamel; bearings double shielded with waterproof non-washing grease.
M. Nominal Efficiency: As scheduled at full load and rated voltage when tested in accordance with IEEE 112.
N. Nominal Power Factor: As scheduled at full load and rated voltage when tested in accordance with IEEE 112.

PART 3 – EXECUTION

3.1 APPLICATION

A. Single phase motors for shaft mounted fans: Split phase type.
B. Single phase motors for shaft mounted fans or blowers: Permanent split capacitor type.
C. Motors located in exterior locations, air cooled condensers explosion proof environments and dust collection systems shall be: Totally enclosed type.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.
B. Install securely on firm foundation. Mount ball bearing motors with shaft in any position.
C. Check line voltage and phase and ensure agreement with nameplate.
D. Replace bearing plugs with grease fittings at project completion.

3.3 NEMA OPEN MOTOR SERVICE FACTOR SCHEDULE

HP	1800 RPM
1/6-1/3	1.35
2	1.25
3/4	1.25
1	1.15
1.5-75	1.15

3.4 PERFORMANCE SCHEDULE: THREE-PHASE – ENERGY-EFFICIENT, OPEN DRIP PROOF

HP	RPM (Syn)	NEMA Frame	Minimum Percent Efficiency	Minimum Percent Power Factor
1	1800	143T	82	84
1-1/2	1800	145T	84	85
2	1800	145T	84	85
3	1800	182T	86	86
5	1800	184T	87	87
7-1/2	1800	213T	88	86
10	1800	215T	89	85
15	1800	256T	91	85
20	1800	256T	91	86
25	1800	284T	91	85
30	1800	286T	92	88

3.5 PERFORMANCE SCHEDULE: THREE-PHASE ENERGY-EFFICIENT (E+3) TOTALLY ENCLOSED, FAN COOLED

HP	RPM (Syn)	NEMA Frame	Minimum Percent Efficiency	Minimum Percent Power Factor
1	1800	143T	82	84
1-1/2	1800	145T	84	85
2	1800	145T	84	85
3	1800	182T	87	83
5	1800	184T	88	83
7-1/2	1800	213T	89	85
10	1800	215T	90	84
15	1800	254T	91	86
20	1800	256T	91	85
25	1800	284T	92	84
30	1800	286T	93	86

END OF SECTION

SECTION 15190

MECHANICAL IDENTIFICATION

PART 1 – GENERAL

1.1 WORK INCLUDED
A. Nameplates.
B. Tags.
C. Stencils.
D. Pipe Markers.

1.2 RELATED SECTIONS
A. Section 15260 - Piping Insulation.
B. Section 15290 – Ductwork Insulation.
C. Section 15410 - Plumbing Piping.
D. Section 15505 - Fuel Piping.
E. Section 15510 - Hydronic Piping.
F. Section 15515 - Hydronic Specialties.
G. Section 15535 – Refrigerant Piping and Specialties.
H. Section 15890 - Ductwork.

1.3 REFERENCES
A. ASME A13.1 - Scheme for the Identification of Piping Systems.

1.4 SUBMITTALS
A. Submit under provisions of Division 1 General Requirements.
B. Submit list of wording, symbols, letter size, and color coding for mechanical identification.
C. Submit valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.
D. Product Data: Provide manufacturers catalog literature for each product required.

1.5 PROJECT RECORD DOCUMENTS
A. Submit under provisions of Division 1 General Requirements.
B. Record actual locations of tagged valves.

PART 2 – PRODUCTS

2.1 NAMEPLATES
A. Manufacturers:
   1. Laco.
   2. Seton.
   3. Brady.
B. Description: Laminated three-layer plastic with engraved black letters on light contrasting background color.

2.2 TAGS
A. Manufacturers:
   1. Laco.
   2. Seton.
   3. Brady
B. Plastic Tags: Laminated three-layer plastic with engraved black letters on light contrasting background color. Tag size minimum 1½-inch diameter.
C. Chart: Typewritten letter size list in anodized aluminum frame.

2.3 STENCILS
A. Stencil: Paint for labeling will not be accepted. All labeling will be with manufacturers labels and letters.

2.4 PIPE MARKERS

A. Color: Conform to ASME A13.1.
B. Plastic Pipe Markers: Factory fabricated, flexible, semi-rigid plastic, preformed to fit around pipe or pipe covering; minimum information indicating flow direction arrow and identification of fluid being conveyed.
C. Plastic Tape Duct Markers: Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings.
D. Underground Plastic Pipe Markers: Bright colored continuously printed plastic ribbon tape, minimum 6 inches wide by 4 mil thick, manufactured for direct burial service.

PART 3 – EXECUTION

3.1 PREPARATION

A. Degrease and clean surfaces to receive adhesive for identification materials.

3.2 INSTALLATION

A. Install plastic nameplates with corrosive resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.
B. Install tags with corrosion resistant stainless-steel chain.
C. Install plastic pipe markers in accordance with manufacturer's instructions.
D. Install underground plastic pipe markers 6 to 8 inches below finished grade, directly above buried pipe.
E. Identify air handling units, pumps, heat transfer equipment, tanks, and water treatment devices with plastic nameplates. Small devices, such as in line pumps, may be identified with tags. Do not identify cabinet/suspended unit heaters, unit ventilators, etc.
F. Identify control panels and major control components outside panels with plastic nameplates.
G. Identify valves in main and branch piping with tags (i.e.: HWS, HWR, BWS, BWR, HW, CW, etc.).
H. Identify air terminal units with numbered tags.
I. Tag automatic controls, instruments, and relays. Key to control schematic.
J. Identify piping, concealed or exposed, with plastic pipe markers. Use tags on piping ¾-inch diameter and smaller. Identify service, flow direction. Install in clear view and align with axis of piping. Locate identification not to exceed 20 feet on straight runs including risers and drops, adjacent to each valve and Tee, at each side of penetration of structure or enclosure, and at each obstruction.
K. Identify ductwork with plastic tape markers. Identify type of service i.e. supply, return, fresh air, exhaust relief and direction of flow. Locate identification at air handling unit, at each side of penetration of structure or enclosure, and at each obstruction.
L. Identify calibrated balancing valves with tags indicating model number, flow rate, service and setting.

3.3 VALVE CHART AND SCHEDULE

A. Provide valve chart and schedule in aluminum frame with clear plastic shield. Install in location directed by Owner.

END OF SECTION

SECTION 15195

TESTING OF HVAC AND GAS PIPING

PART 1 – GENERAL

1.1 WORK INCLUDED
A. Heating hot water and chilled water piping (HCWS/R, CWS/R, HWS/R and BWS/R).
B. Chemical feed piping.
C. Natural gas piping.
D. Refrigerant piping.

1.2 RELATED SECTIONS
A. Section 15505 - Fuel Piping.
B. Section 15510 - Hydronic Piping.
C. Section 15535 – Refrigerant Piping and Specialties.
D. Section 15545 – Chemical Water Treatment.

1.3 REFERENCES
A. NFPA.
B. ARI.
C. International Mechanical Code 2015.

1.4 REGULATORY REQUIREMENTS
A. Conform to International Mechanical Code 2015.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

(Not Used.)

PART 3 – EXECUTION

3.1 GENERAL
A. Before final acceptance of all HVAC and gas piping systems, all systems must be tested in accordance with the schedule and prove to be free of leaks.
   1. Perform tests under observation of Architect/ Engineer.
   2. Remove, replace or satisfactorily repair defective work revealed by tests.
   3. Make piping repairs with new materials; caulking of screwed joints or pin holes is not permitted.
   4. Furnish all test equipment and materials for testing.
   5. Owner to furnish water for testing and flushing.

3.2 TESTING MATERIAL
A. Testing Medium:
   1. Hydrostatic Testing Medium: Clean water.
   2. Pneumatic Testing Medium: Clean compressed air.
B. Pressure Testing Gauges: ANSI B40.1, Grade AA; minimum 6-inch diameter dial with scale divisions equal or less than maximum allowable pressure drop.

3.3 TESTING SYSTEMS

A. All plumbing and fire protection piping to be tested as called for in Section 15410.
B. HVAC and Gas System Piping:
   1. Test with water and air.
   2. Water Test:
      a. When entire system is tested, tightly close all openings in pipes except highest opening and fill system with water to overflow point.
      b. When system is tested in sections, tightly plug each opening except highest opening, fill each section with water and test each section with minimum 10-foot head of water; test each preceding section until entire system has been tested with minimum 10-foot head of water, except uppermost 10 feet of system.
      c. Keep water in system or in portion under test, for minimum 30 minutes before inspection.
      d. System must be tight at all joints.
   3. Air Test:
      a. When tests are made with air, apply minimum 30 psi with force pump and maintain for period of time indicated in Paragraph D with no leakage apparent.
      b. Use mercury-column in making test.
C. Hydrostatic and Pneumatic Testing Requirements:
   1. Hydrostatic and pneumatic tests apply to piping indicate as scheduled is Paragraph D.
   2. Pressure to be raised gradually to given value; then block off tight at source.
   3. Allowable Pressure Drop: Maximum amount scheduled during corresponding minimum time interval.
      a. Visually examine all joints during test.
   4. Upon successful completion and test approval, relieve piping of pressure, drain, put into normal operation except for potable water to be sterilized before placing in service.
D. Hydrostatic and Pneumatic Testing Schedule:

Service	Normal Hydrostatic Work Pressure psig	Pneumatic Test Pressure psig	Maximum Allowable Test Pressure psig	Minimum Pressure Drop psi	Test Time Hours
1.Water:					
Hot/Chilled/ Water, Chilled Water, Hot Water and Boiler Water	To 60	150	30	2	8
2. Fuel					
Natural Gas	To 5	---	30	0	8
3. Miscellaneous					
Refrigeration	To 290	---	300	0	4
Chemical Feed	To 60	---	30	0	4

3.4 CLEANING AND ADJUSTING

A. Cleaning: Thoroughly clean all parts of the piping installation at completion of work.
   1. Remove grease, metal cutting and sludge from all equipment, pipes, valves all fittings.
   2. Repair all stoppages, discoloration or other damage to finish, furnishings or parts of building that are due to Contractor's failure to properly clean piping system.
   3. Remove and clean all flow control devices.

B. Adjusting:
   1. Adjust all valves and other parts of work for quiet operation.
   2. Adjust control devices for proper operation.
   3. Demonstrate to Architect/Engineer satisfactory operation following adjustment.
   4. Readjust or replace all items not functioning properly.

END OF SECTION

SECTION 15242

VIBRATION ISOLATION

PART 1 – GENERAL

1.1 WORK INCLUDED
A. Vibration isolation for piping and equipment.
B. Piping flexible connections.

1.2 RELATED EQUIPMENT SECTIONS
A. Section 15410 – Plumbing Piping.
B. Section 15510 – Hydronic Piping.
C. Section 15535 – Refrigerant Piping and Specialties.
D. Section 15540 – Pumps.
E. Section 15620 – Indoor Condenserless Liquid Water Chiller with Remote Condenser.
F. Section 15790 – Air Coils.
G. Section 15836 – Terminal Heat Transfer Units.
H. Section 15870 – Power Ventilators.
I. Section 15890 – Ductwork.

1.3 REFERENCES
A. ASHRAE – Guide to Average Noise Criteria Curves.

1.4 QUALITY ASSURANCE
A. Maintain ASHRAE criteria for average noise criteria curves for all equipment at full load condition.
B. Provide all vibration isolators and equipment bases for Division 15 work from the product line of a single manufacturer, unless otherwise accepted by the Acoustics Consultant.
C. Provide all vibration isolators and equipment bases for Division 16 work from the product line of a single manufacturer, unless otherwise accepted by the Acoustics Consultant.
D. Select isolators to provide uniform deflections within acceptable tolerances when supporting the equipment approved for this project. Coordinate as required with the equipment manufacturers to accomplish this.
E. Provide engineering, isolator selection, site supervision, and inspection by manufacturer's personnel who shall perform these services directly. Alert the Engineer of isolator selections that may result in resonances with the equipment and structural systems they are intended to isolate. Replace isolators that upon installation are found to resonate with the supported equipment.
F. Provide complete isolation systems that include all elements recommended by the manufacturer for compliance with project requirements and applicable codes, ordinances, and regulations. Include all incidental products and materials required for a complete installation even if not explicitly described in the Construction Documents.
G. Install vibration isolation systems using skilled workers trained and licensed, as applicable, by the manufacturer for installations of the types used on this project. Upon completion of the Work, provide final inspection by the manufacturer's representative and submit to the Architect and Engineer a written report authored by the manufacturer's representative certifying the correctness of installation and compliance with the approved submittal data. Include tabulation of the static deflection expected under design and operating loads in comparison with the actual static deflection measured in the completed installations.

1.5 UNACCEPTABLE TYPES
A. Do not use housed spring mounts on this project. Mason models C, CI, and CS; Amber-Booth models XI and XK; Kinetics SL and SM; and similar mounts are not acceptable.
B. Do not use captive spring mounts on this project. Provide seismic restraint by means of resilient snubbers at the perimeter of the equipment or equipment base and not by mounts that combine isolation and snubbing functions. Mason model SSLFH, Amber-Booth model SWPQ, and similar mounts are not acceptable.
C. Do not use cork as an isolation material.

D. Do not use braided metallic hose for vibration isolation in piping unless fluid temperatures and pressures are beyond the service range of spherical elastomeric isolators.

1.6 SUBMITTALS

A. Submit manufacturer's data, shop drawings, and product performance certifications in accordance with Division 1.
B. Manufacturer's Data: Submit technical product data confirming that products comply with specified requirements:
   1. Illustrations and descriptions of components including, but not limited to isolators, equipment bases, thrust and seismic restraints, anchors, and accessories.
   2. Operation and maintenance instructions.
C. Shop Drawings
   1. Full-size details of isolation systems, including plan and section drawings indicating isolator and flexible connection locations and types, isolator and connector schedules, and installation details.
   2. Indicate substrate construction required of other subcontractors.
D. Color code legend for spring and elastomer capacities.
E. Samples: provide a sample of each type of isolator assembly used in the project. It is not necessary to submit samples of each spring capacity and pad hardness.
F. Calculations: submit manufacturer's engineer's calculations of loads, deflections, and natural frequencies for record only.
G. General Requirements for Vibration Isolation Mounts and Hangers: Provide catalog cut sheets, shop drawings, and other documents as necessary to describe the installation and its components.
   1. Springs:
      a. Equipment name and number
      b. Operating Weight of Equipment
      c. Lowest reciprocating or rotating speed
      d. Isolator type
      e. Weight supported by isolator
      f. Scheduled deflection
      g. Proposed deflection under operating load
      h. Natural Frequency
      i. Spring free height
      j. Spring operating height
      k. Spring solid height at coil bind
      l. Spring diameter
   2. Elastomeric Pads:
      a. Equipment name and number
      b. Operating Weight of Equipment
      c. Isolator type
      d. Weight supported by isolator
      e. Pad bearing area
      f. Pad free height
      g. Pad operating height
      h. Scheduled deflection
      i. Proposed deflection under operating load
      j. Percent deflection
      k. Natural Frequency
      l. Hardness and compliance with AASHTO Bridge Bearing Neoprene quality standard

1.7 REGULATORY REQUIREMENTS

A. Conform to 2009 International Mechanical Code.

1.8 MANUFACTURER RESPONSIBILITIES

A. Manufacturer of vibration isolation equipment shall have the following responsibilities:
   1. Determine vibration isolation sizes and locations.
   2. Provide piping and equipment isolation systems as scheduled or specified.
   3. Guarantee specified isolation system deflection.
   4. Provide installation instruction, drawings, and field supervision to assure proper installation and performance.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers listed below have demonstrated an ability to comply with specifications for vibration isolation products similar to those required for this project. However, specific products made by the listed manufacturers do not all comply with the requirements of this specification. Subject to the requirement for a single manufacturer and the restrictions regarding unacceptable types of isolators, the products of the following manufacturers are acceptable sources for this project:
   1. Mason Industries, Inc.
   2. Kinetics Noise Control.
   3. Amber-Booth Company, Inc.
   4. E.A.R.
   5. PSI-Thunderline/Link-Seal.
   6. Ductmate Industries, Inc.
   7. Unger Technologies.

2.2 SPRING REQUIREMENTS

A. Provide steel springs with static deflections equal to or greater than those shown on the Construction Documents. Submittals based on rated deflections will be rejected.
B. Unless otherwise noted, size springs to provide a natural frequency of not more than 3 Hertz. Where spring deflections called out in the Construction Documents exceed those required to achieve a natural frequency of 3 Hz or less, the greater deflection will govern.
C. Size springs to provide not less than 50 percent additional travel to solid, coil-bind condition beyond the deflection under operating load.
D. Size springs so that diameter is not less than 80 percent of the height of the spring at operating load.
E. Provide springs that do not permanently deflect after loading to a solid, coil-bind condition.
F. Do not weld springs to other components of the isolator assembly unless specifically noted in the Submittals and accepted by the Acoustics Consultant.
G. Color code springs to allow positive identification after installation. Match color coding to the color code legend provided with the submittals.

2.3 ELASTOMER REQUIREMENTS

A. Provide elastomeric elements with static deflections equal to or greater than those shown on the Construction Documents. Submittals based on rated deflections will be rejected.
B. Provide neoprene elements with a maximum hardness of 40 durometer, Shore A rating, where possible, but in no case exceeding 50 durometer. Where deflections called out in the construction documents exceed those required to achieve the specified natural frequencies, the greater deflection will govern.
C. Meet AASHTO Highway Bridge Specifications for all neoprene products installed in irretrievable locations and as required elsewhere in the Construction Documents.

2.4 ACCEPTABLE PRODUCTS

A. (Type A) Elastomeric Pads: 5/16-inch minimum thickness, waffled or ribbed neoprene. Where multiple layers are required to provide the specified deflections, interleave pads with 16-gauge steel shim plates. Size pads for deflection equal to 10 to 15 percent of unloaded height and provide pads of sufficient thickness to achieve the specified deflection. Provide load-distributing top plates if required for uniform loading. Acceptable products include
   1. Individual pads
      a. Mason W, SW, and Super W
      b. Kinetics NP
      c. Amber-Booth NR
   2. Neoprene/Steel composite pads:
      a. Mason WSW
      b. Amber-Booth SP-NR Style E

B. (Type B) Neoprene-In-Shear Base-Mounted Isolators: Provide double-deflection isolators with steel bottom plates with pre-drilled bolt holes for attachment to floor or base, a threaded steel insert at the top of the isolator for attaching the equipment, and friction surfaces at both top and bottom. Coat all metal surfaces with neoprene. Design isolators for 0.25 to 0.35 inches of deflection. Acceptable products include:
   1. Neoprene-In-Shear Isolators:
      a. Mason ND
      b. Kinetics RD
      c. Amber-Booth RVD

C. (Type D) Restrained Open Spring Base-Mounted Isolators: Provide built-in adjustable spring restraints for equipment with operating weight greater than weight upon installation to prevent equipment from deflecting (or rising) when the additional weight is applied (or removed in the future). Provide isolators as specified for Type C but with restraint studs and adjustable nuts. Provide ½ inch minimum clearance around the restraint studs. Use bridge-bearing quality neoprene for elastomeric friction pads at chillers and cooling towers. Acceptable products include:
   1. Restrained Base Mounted Isolators:
      a. Mason SLR
      b. Kinetics FLS
      c. Amber-Booth CT

D. (Type F) Spring Hangers: Provide spring of the general characteristics specified in Paragraph 2.2, above in a rigid steel hanger box. Seat spring in a molded neoprene cup with steel washer reinforcing. Mold neoprene element with a rod isolation bushing that prevents rigid contact between hanger rod and housing from vertical through an angular deflection of not less than 15 degrees in any direction. For ductwork hung by straps, provide hangers with eyes on the top and bottom to allow for bolting to the straps. Acceptable products include:
   1. Spring hangers:
      a. Mason types 30 and W30

E. (Type G) Spring/Elastomer-in-Series Hangers: Provide neoprene-in-shear element of 1¼-inch minimum thickness and a spring of the general characteristics specified in Paragraph 2.2, above. Seat spring in a molded neoprene cup with steel washer reinforcing. Mold neoprene element with a rod isolation bushing that prevents rigid contact between hanger rod and housing from vertical through an angular deflection of not less than 15 degrees in any direction. Design neoprene for .25 to .35-inch minimum static deflection at rated load. Do not directly stack the spring and neoprene isolator elements. For ductwork hung by straps, provide hangers with eyes on the top and bottom to allow for bolting to the straps. Acceptable products include:
   1. Spring/Elastomer-in-Series Hangers:
      a. Mason 30N
      b. Kinetics SRH
      c. Amber-Booth BSRA

F. (Type H) Pre-compressed Spring/Elastomer-in-Series Hangers: Provide built-in adjustable spring restraints for equipment with operating weight greater than weight upon installation to prevent equipment from deflecting (or rising) when the additional weight is applied (or removed in the future). Provide isolators as specified in Subparagraph G but pre-compressed with restraint mechanisms that can be released to free the spring when subjected to its operational load. Provide an integral scale to indicate amount of deflection. For ductwork hung by straps, provide hangers with eyes on the top and bottom to allow for bolting to the straps. Acceptable products include:
   1. Pre-compressed Spring/Elastomer-in-Series Hangers:
      a. Mason PC30N
      b. Amber-Booth PBSRA

G. (Type G) Floating Concrete Bases: Vibration isolator manufacturer shall furnish rectangular structural beams or channel concrete forms for floating foundations. The base depth need not exceed 12” unless specifically recommended by the base manufacturer for mass or rigidity. In general, bases shall be a minimum of 1/12th of the longest dimension of the base, but not less than 6”. Forms shall include minimum concrete reinforcement consisting of half-inch bars or angles welded in place on 6” center running both ways in a layer 1-1/2” above the bottom, or additional steel as in required by the structural conditions. Forms shall be furnished with steel members to hold an anchor-bolt sleeves when the anchor bolts fall in concrete locations. Height saving brackets shall be employed in all mounting locations to maintain a 1” clearance below the base.
   1. Acceptable Manufacturers:
      a. Mason Industries – Type K.
      b. Korfund Dynamics.
      c. Amber Booth.

H. (Type P) Flexible Neoprene Piping Connectors: Provide flanged twin-sphere or threaded single-sphere isolators with Kevlar cord and peroxide-cured EPDM body with steel rings embedded in flanges to prevent pull-out. Connectors must accept elongation, compression, axial, and transverse motion. Select materials to suit system temperature, pressure, and fluid type. Do not use control rods or cables to limit extension of the isolator. Use twin-sphere isolators for pipes 2 inches to 14 inches in diameter. Single-sphere isolators may be used for pipes less than 2 inches and greater than 14 inches in diameter. Straight-wall flexible connectors are not acceptable except for sewage ejector pumps. Acceptable products include:
   1. Flexible Neoprene Piping Connectors:
      a. Mason types SFDEJ, SFDCR, and SFU

I. (Type Q) Flexible Duct Connections: Provide Hypalon-coated, woven fiberglass, flameproof fabric (24 oz per square yard), serviceable from -40°F to 250°F. Acceptable products include:
   1. Ductmate Pro-Flex

J. (Type S) Elastomeric Isolators for Mounting Bolts: Provide neoprene grommets, bushings, and washers for all bolts used to secure isolators to floors and housekeeping slabs and for all snubbers. Size bolt holes and washers to accommodate grommets, sleeves, and bushings and to preclude contact between rigid components that would cause bridging between isolated elements and the building structure. Baseplates for neoprene pads may be rigidly bolted to the floor or housekeeping slab if the bolts secure the baseplates only and do not continue through the neoprene to meet any other rigid material. Do not exceed 40 durometer, Shore A hardness. Acceptable products include:
   1. Grommets (Washer Bushings):
      a. Mason HG
      b. E.A.R. Isodamp and C-1000
   2. Bushings:
      a. Mason HLB
   3. Washers:
      a. Mason HLW

PART 3 – EXECUTION

3.1 INSTALLATION

A. General:
   1. Install in accordance with manufacturer's written instructions. Vibration isolators must not cause any change of position of equipment or piping resulting in piping stresses or misalignment.
   2. Mechanical equipment shall be isolated from the building structure by means of noise and vibration isolators as scheduled on the drawings.
   3. All piping and vertical risers shall be isolated from the building structure by means of noise and vibration isolation guides and supports.
   4. All piping and ductwork to be isolated shall freely pass through walls and floors without rigid connections. Penetration points shall be sleeved or otherwise formed to allow passage of piping or ductwork and maintain 3/4" to 1 1/4" clearance around the outside surfaces. This clearance space shall be tightly packed with fiberglass and caulked airtight after installation of piping or ductwork.
   5. No rigid connections between equipment and building structure shall be made that degrades the noise and vibration isolation system herein specified.
   6. Electrical circuit connections to isolated equipment shall be looped to allow free motion of isolated equipment.
   7. The Contractor shall not install any equipment, piping or conduit which makes rigid contact with the "building" unless permitted in the Specification. Building includes, but is not limited to slabs, beams, columns, studs and walls.
   8. Coordinate work with other trades to avoid rigid contact with the building. Inform other trades following work, such as plastering or electrical, to avoid any contact which would reduce the vibration isolation.
   9. Bring to the Architect's attention prior to installation any conflicts with other trades which will result in unavoidable rigid contact with equipment or piping as described herein, due to inadequate space or other unforeseen conditions. Corrective work necessitated by conflicts after installation shall be at the responsible contractor's expense.
   10. Bring to the Architect's attention any discrepancies between the specifications and field conditions or changes required due to specific equipment selection, prior to installation. Corrective work necessitated be discrepancies after installation shall be at the contractor's expense.
   11. Obtain inspection and approval of any installation to be covered or enclosed, prior to such closure.
   12. Correct, at no additional cost, all installation which are deemed defective in workmanship or materials.
   13. For all isolated equipment, make connections of piping, ductwork, and conduit using flexible connections specified in this section. Make no connections to isolated equipment in a manner that would compromise the performance of the isolation systems.

3.2 MOUNTS AND HANGERS

A. Align mounts and hangers squarely above or below the equipment mounting holes to avoid introducing lateral loads and deflection.
B. Deflection requirements:
   1. Verify installed isolators have deflections equal to or greater than deflections specified on the submittals.
   2. Where multiple deflections apply to a single isolator (where a single isolator supports multiple isolated elements), the largest deflection governs.
   3. Vary the size and/or hardness of isolators as required to yield equal deflection for all isolators supporting a single piece of equipment or length of pipe or ductwork. Consult manufacturer for direction when specified isolators do not yield required deflection and correct non-compliant isolators at no cost to the Owner.

C. Support equipment, ductwork, conduit and piping independently. Do not hang equipment, ductwork, piping, or conduit from other isolated equipment, ductwork, piping, or conduit.
D. Maintain 2 inches of clearance between isolated elements and walls, ceilings, and other non-isolated building components.
E. Isolate drain piping attached to vibration isolated equipment from rigid components of the building.
F. Limit stops must be inactive and out of contact with the isolator during equipment operation.
G. Adjust leveling bolts and hanger rod lengths so that equipment is level and in alignment with connecting ductwork and piping.
H. Restrained isolators may be substituted for unrestrained isolators at installer's option to simplify installation.

3.3 SUSPENDED EQUIPMENT

A. Fans, Cabinet/Suspended Unit Heater, and Fan Coil Units.
   1. Resiliently hang fans and fan coil units with Type G spring/elastomer-in-series isolators.
   2. Connect ductwork with Type Q flexible duct connections at inlet and discharge. Connect fan coil piping with Type P flexible piping connectors.
   3. Provide flexible electrical connections.

3.4 PIPING AND CONDUIT

A. Isolate all piping 1½ inches and larger in diameter that is connected to rotating or reciprocating equipment. Waste, vent, rainwater, and fire protection piping do not require isolation unless noted otherwise.
B. Select and install isolators in a manner that does not induce stresses in piping connections and does not result in misalignment of shafts and bearings. Maintain equipment and piping in rigid condition during installation. Do not transfer loads to the isolators until the installation is complete and under full operational load.
C. Isolator Types:
   1. For equipment isolated with supports and mounts containing springs, provide Type G or H spring/elastomer-in-series isolators for the first 4 horizontal piping hangers and associated vertical piping. Size these hangers to provide the same static deflection as the isolators for the equipment. For floor-supported piping, use Type D open spring base mount isolators and Type B neoprene-in-shear base mount isolators.
   2. Beyond the 4 hangers nearest the equipment, within the rooms housing the equipment and for a distance of not less than 50 feet from the equipment, provide Type F elastomeric hangers, and provide Type F hangers for all piping of 2-inch and smaller diameter and flow rates of greater than 4 feet per second.
   3. For pipes larger than 2-inch and not greater than 6-inch diameter throughout the building, support entire length on Type F elastomeric hangers, Type B neoprene-in-shear base supports, or Type A elastomeric pads between the piping and all points of contact between piping and non-isolated construction.
   4. For pipes larger than 6-inch diameter, support entire length throughout the building on Type H restrained spring/elastomer-in-series hangers, or Type D restrained spring/elastomer-in-series base mounts if supported from the floor.
D. Position isolators as high as possible in the hanger rod or strap assembly but not in direct contact with the building structure without manufacturer's written authorization. Provide 1-inch minimum clearance between isolator housing and structure above. Provide side clearance for hangers to allow full 360-degree rotation about the rod axis without contacting any object.
E. Parallel pipes can be hung together on a trapeze that is isolated from the structure. Isolator deflections must be equal to or greater than the greatest deflection required for the pipes if isolated individually. Do not mix isolated and non-isolated piping on the same trapeze.
F. Mount flexible connections for piping to equipment on the equipment side of shut-off valves.
G. Provide isolation of expansion tanks, air separators, and other devices similar to that provided for the attached piping.

3.5 DUCTWORK

A. Connect ductwork to equipment using Type Q flexible duct connections. Crimp fabric into duct flanges and seal airtight. Provide minimum separation of 6 inches between duct and equipment. Provide 1½ inch minimum slack or as required to accommodate full range of equipment and duct movement when subjected to maximum operating and lateral loads simultaneously without becoming taut. Utilize Type I thrust restraints to limit horizontal movement so that flexible connections do not become taut under any combination of operational loads. Mount flexible duct connections as close to equipment housings as practical but in no case beyond the first duct hanger.

B. Duct Connections at Rigidly-Mounted Fire Dampers: Provide Type Q flexible duct connections at each side of all fire dampers rigidly connected to the associated partition construction.

C. Isolator Types:
   1. Provide Type G spring/elastomer-in-series hangers for the first 3 duct hangers from the equipment. Provide hangers with minimum static deflection equal to that of the isolators supporting the equipment.
   2. Beyond the first 3 hangers, support all ductwork with short-side dimension less than 24 inches in the following manner:
      a. Support with Type F elastomeric hangers, Type B neoprene-in-shear base mounts, or Type A elastomeric pads at all points of support within 50 feet of the equipment to which the ductwork connects.
      b. Beyond 50 feet from the equipment, no isolation is required unless the ductwork is supported from construction enclosing Acoustically Sensitive or Critical Rooms, in which case provide the isolators described in (a).
   3. Beyond the first 3 hangers, support ductwork with short-side dimension of 24 inches or greater in the following manner:
      a. Support with Type H pre-compressed spring/elastomer-in-series hangers or Type E restrained open spring base mount isolators for a minimum of 50 feet from the equipment.
      b. If air velocities exceed 800 feet per minute, continue the isolators for an additional 50 feet.
      c. In addition to the requirements of (a) and (b), provide isolators for all ductwork with velocities exceeding 800 feet per minute that is supported from Acoustically Sensitive or Acoustically Critical Rooms or that is otherwise indicated on the Drawings to receive isolation.
   4. Vertical Ductwork:
      a. Support vertical ductwork for the 3 supports nearest the equipment with Type D open mount spring isolators with minimum deflections equal to or greater than the isolators supporting the equipment.
      b. Thereafter, support all vertical ductwork with short-side dimension less than 24 inches with Type B neoprene-in-shear isolators for not less than 50 feet from the equipment.
      c. Support all vertical ductwork with short-side dimension equal to or greater than 24 inches and all other ductwork indicated on the Drawings to receive isolation on Type D open spring base mount isolators.

3.6 EQUIPMENT SCHEDULE

A. Equipment to be installed on isolators:
   1. Inline Exhaust fans.
   2. Ceiling cabinet unit heaters.
   3. Suspended unit heaters.
   4. Air cooled condensing units.
   5. Chillers.
   6. Inline pumps.
   7. Ceiling fan coil units.

3.7 TESTING, EVALUATION AND ACCEPTANCE PROCEDURES

A. If it is found that the construction fails the acoustic test measurements or performance requirements identified in the Contract Documents, make changes necessary to meet the requirements identified in the Contract Documents and be responsible for the costs associated with performing all additional acoustical tests to verify the acoustic performance of the construction. Costs for additional acoustical testing shall include consulting fees at per hour rates in effect at the time of testing along with related expenses including, but not limited to, travel expenses and test equipment use charges.

END OF SECTION

SECTION 15260

PIPE INSULATION

PART 1 – GENERAL

1.1 WORK INCLUDED
A. All plumbing and hydronic piping jackets and accessories.
B. All piping saddles.
C. Generator exhaust/muffler.

1.2 RELATED SECTIONS
A. Section 15140 - Supports and Anchors: Pipe covering protection shields.
B. Section 15190 - Mechanical Identification.
C. Section 15410 - Plumbing Piping.
D. Section 15510 - Hydronic Piping.
E. Section 15515 - Hydronic Specialties.
F. Section 15535 - Refrigerant Piping and Specialties.

1.3 REFERENCES
A. ASTM C335 - Steady-State Heat Transfer Properties of Horizontal Pipe Insulation.
B. ASTM C449 - Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement.
C. ASTM C518 - Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
D. ASTM C534 - Preformed Flexible Elastomeric Cellular Thermal Insulation in Sheet and Tubular Form.
E. ANSI/ASTM C547 - Mineral Fiber Preformed Pipe Insulation.
F. ASTM C585 - Inner and Outer Diameters and Rigid Thermal Insulation for Nominal Sizes of Pipe and Tubing (NPS System).
G. ASTM C921 - Properties of Jacketing Materials for Thermal Insulation.
H. ASTM D1667 - Flexible Cellular Materials - Vinyl Chloride Polymers and Copolymers (Closed Cell Foam).
I. ASTM D2842 - Water Absorption of Rigid Cellular Plastics.
J. ASTM E84 - Surface Burning Characteristics of Building Materials.
K. ASTM E96 - Water Vapor Transmission of Materials.

1.4 REGULATORY REQUIREMENTS
A. Conform to 2015 International Mechanical Code and International Energy Conservation Code 2018.

1.5 SUBMITTALS
A. Submit under provisions of Division 1 General Requirements.
B. Product Data: Provide product description, list of materials and thickness for each service and locations.
C. Submit manufacturer's installation instructions under provisions of Division 1 General Requirements.
D. Contractor shall review all shop drawings prior to submitting them for Architect/Engineer's review. Contractor shall stamp each shop drawing to certify that he has reviewed it. Engineer will not check any shop drawings that Contractor has not stamped with his review certification.

1.6 QUALITY ASSURANCE
A. Materials: Flame spread/fuel contributed/smoke developed rating of 25/50 or less in accordance with ASTM E84. Material shall not melt or drip when exposed to flame.

1.7 QUALIFICATIONS
A. Applicator: Company specializing in performing the work of this Section with minimum five years’ experience.

1.8 DELIVERY, STORAGE AND HANDLING

A. Deliver products to site under provisions of Division 1 General Requirements.
B. Store, protect and handling products under provisions of Division 1 General Requirements.
C. Deliver materials to site in original factory packaging, labeled with manufacturer's identification, including product density and thickness.

1.9 ENVIRONMENTAL REQUIREMENTS

A. Insulation Work:
   1. Maintain ambient temperatures and conditions for installation of insulation as required by manufacturers of insulation adhesives, mastics and insulation cements.

PART 2 – PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Insulation:
   1. Manville Corporation.
   2. Knauf Fiberglass.
   3. CertainTeed Corp.
   4. Owens Corning Fiberglass.
B. Steel and Wood Insulation Protection Saddles:
   1. Acceptable Manufacturers:
      a. Grinnell.
      b. B-Line.
      c. Unistrut.

2.2 FIBER GLASS INSULATION MATERIALS (TYPE A):

A. Glass Fiber Insulation
   1. Insulation: ASTM C547; rigid molded, noncombustible.
      a. K Value: 0.23 at 75 degrees F.
      b. Minimum Service Temperature: 0 degrees F.
      c. Maximum Service Temperature: 850 degrees F.
      d. Maximum Moisture Absorption: 0.2 percent by volume.
   2. Vapor Barrier Jacket:
      a. ASTM C921; factory applied vapor retarder composed of a white draft facing out reinforced with glass fiber yarn and bonded to aluminized film (ASJ).
      b. Moisture Vapor Transmission: ASTM E96; 0.02 perm inches.
      c. Secure with factory applied self-sealing longitudinal laps and butt strips.
      d. Jacket Temperature Limit: Minus 20 to 150 degrees F.
   3. Vapor Barrier Lap Adhesive:
      a. Compatible with insulation.
   4. Fittings (Concealed and Exposed):
      a. Insulate all fittings (plumbing and HVAC) with a minimum of two layers of precut blanket insulation.
      b. Insulation blanket thickness to equal K value of straight sections of insulation.
      c. Tie wire to be 18-gauge stainless steel with twisted ends.
      d. Jacket shall be a one-piece pre-molded high impact fitting 25/50 rated, off-white color, 10 mil thick, brush on welding adhesive connections.
   5. Insulating Cement/Mastic:
      a. Acceptable Manufacturers:
         1) Fibrex.
         2) Pabco.
         3) Manville.
      b. ASTM C195; hydraulic setting on mineral wool.

2.3 ELASTOMERIC CELLULAR FOAM (TYPE B):

A. Manufacturers:
   1. Armstrong World Industries - Model AP Armaflex.
   2. Halstead.
   3. Rubatex.

B. Insulation: ASTM C534; flexible, cellular elastomeric, molded or sheet.
   1. K Value: ASTM C177 or C518; 0.27 at 75 degrees F.
   2. Minimum Service Temperature: -20 degrees F.
   3. Maximum Service Temperature: 220 degrees F.
   4. Maximum Moisture Absorption: ASTM D1056; 1.0 percent (pipe) by volume, 1.0 percent (sheet) by volume.
   5. Moisture Vapor Transmission: ASTMA E96; 0.20 perm inches.
   6. Maximum Flame Spread: ASTM E84; 25.
   7. Maximum Smoke Developed: ASTM E84; 50.
   8. Connection: Waterproof vapor barrier adhesive.

C. Elastomeric Foam Adhesive:
   1. Acceptable manufacturers:
      a. Armstrong - Model 520.
   2. Air dried, contact adhesive, compatible with insulation.

2.4 HYDROUS CALCIUM SILIICATE INSULATION (TYPE C)

A. Insulation: ASTM C533; rigid molded white, asbestos free.
   1. K Value: ASTM C177 and C518: 0.44 at 300-degrees F.
   2. Maximum Service Temperature: 1500-degrees F.
   3. Density: 13 lb./cu. ft.
   4. Thermal Ceramics.

B. Tie Wire: 18-gauge stainless-steel with twisted ends on maximum 12 in. centers.

C. Insulation Cement:
   1. ASTM C449.

2.5 JACKETS

A. PVC Plastic (Fittings and ALL Exposed Interior Piping excluding Mechanical Room 40, Mechanical Room 59, Storage Room 58, Existing MDF 57, Storage Room 41, Storage Room 54, Electric 53, Existing Electrical 28A, Janitors Closets and Existing Mechanical/Storage B09.
   1. Jacket: ASTM C921, one-piece molded type fitting covers and sheet material, off-white color.
      a. Minimum service temperature: -40 degrees F.
      b. Maximum service temperature: 150 degrees F.
      c. Moisture vapor transmission: ASTM E96; 0.002 perm-inches.
      d. Maximum Flame Spread: ASTM E84; 25.
      e. Maximum Smoke Developed: ASTM E84; 50.
      f. Thickness: 10 mil.
      g. Connections: Brush on welding adhesive.

B. Aluminum Jacket: ASTM B209 (All exterior refrigerant piping serving air cooled condenser).
   1. Thickness: 0.016-inch sheet.
   2. Finish: Embossed.
   3. Joining: Longitudinal slip joints and 2-inch laps.
   4. Fittings: 0.016-inch thick die shaped fitting covers with factory attached protective liner.
   5. Metal Jacket Bands: 3/8-inch wide; 0.010-inch thick stainless steel.

C. Water Based Armaflex Finish: ASTM 84 (all exterior suction refrigerant piping service air cooled condenser)
   1. Color: Standard white.
   2. Composition: Pigmented Acrylic Latex.
   3. Flammability: Nonflammable; water based.
   4. Application: Brass or roller.

PART 3 – EXECUTION

3.1 INSULATION

A. Examination:
   1. Verify that piping has been tested before applying insulation materials.
   2. Verify that surfaces are clean, foreign material removed and dry. Flux to be removed from copper piping.

B. Installation:
   1. Install materials in accordance with manufacturer's instructions.
   2. On exposed piping, locate insulation and cover seams in least visible locations.
   3. All insulation to have a vapor barrier jacket (ASJ) with factory applied self-sealing longitudinal laps and butt strips.
   4. Support all piping with insulation protection saddles.
      a. Plumbing Piping:
         1) 2-Inch Pipe Size: Wood dowel with insulation shields.
         2) ¾-Inch and Larger: High density pre-molded type with insulation shields or manufactured wood saddles.
      b. Hydronic Piping:
         1) 2-Inch to 2½-Inch: High density pre-molded type with insulation shields.
         2) 3-Inch and Larger: Manufactured steel saddles welded to the pipe.
   5. Run insulation continuous through walls, floors, sleeves, pipe hangers and other pipe penetrations.
   6. Insulate all piping located behind chases.
   7. Insulate all piping installed inside cabinet unit heaters and fan coils.
   8. **Insulate entire system including fittings, valves, unions, flanges, strainers, expansion joints, pump bodies, chemical feeders, rolairtrols, chemical feed piping from pot feeders and separators, including heating piping.**
   9. Finish all insulation at supports, protrusions and interruptions.
   10. Seal all aluminum jackets outdoors air and water tight.
   11. Exterior Applications: Provide vapor barrier jacket. Insulate fittings, joints and valves with insulation of like material and thickness as adjoining pipe, and finish with glass mesh reinforced vapor barrier cement. Cover with aluminum jacket with seams located on bottom side of horizontal piping.

3.2 INSULATION SCHEDULE

PIPING SYSTEMS	INSULATION TYPE	PIPE SIZES/INSULATION THICKNESS ½" To 1"	1¼" To 2"	2½" To 4"	5" & Larger
A. Plumbing and Mechanical Systems					
Domestic Cold Water Supply	A	1"	1"	2"	2"
Domestic Hot Water Supply	A	1"	1"	2"	2"
Domestic Hot Water Recirc. (HWC)	A	1"	1"	2"	2"
Heating Water (HWS&R) and Boiler Water (BWS&R)	A	1½"	1½"	2"	2"
Hot/Chilled Water (HCWS&R) and Chilled Water (CHWR&R)	A	1"	1"	2"	3"
Refrigerant Suction and Hot Gas	B	1"	1"	1½"	--- (Exterior Piping Shall Include Aluminum Jacket)
Condensate Dew Drain Pipes (if installed in copper or steel pipe)	A	½"	½"	1"	1"
Storm, Roof Drains and Horizontal Conductors	A	½"	½"	1"	1"
Plumbing Vents Within 10 Feet of Exterior	A	½"	½"	1"	1"
Sanitary Drainage From Mech. Equipment Rooms	A	½"	½"	½"	½"
Generator Exhaust Pipe and Muffler	C	4"	4"	4"	4" (Finish with Aluminum Jacket)

Note: ALL exposed interior piping shall have a PVC jacket as specified.

END OF SECTION

SECTION 15280

EQUIPMENT INSULATION

PART 1 – GENERAL

1.1 WORK INCLUDED
A. Equipment insulation.
B. Covering.

1.2 RELATED SECTIONS
A. Section 15190 - Mechanical Identification.
B. Section 15260 – Pipe Insulation.
C. Section 15515 – Hydronic Specialties.
D. Section 15540 – HVAC Pumps.

1.3 REFERENCES
A. ASTM A167 - Standard Specification for Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip.
B. ASTM C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
C. ASTM C195 - Standard Specification for Mineral Fiber Thermal Insulation Cement.
D. ASTM C449/C449M - Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement.
E. ASTM C518 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
F. ASTM C553 - Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
G. ASTM C612 - Standard Specification for Mineral Fiber Block and Board Thermal Insulation.
H. ASTM C921 - Standard Practice for Determining the Properties of Jacketing Materials for Thermal Insulation.
I. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
J. ASTM E96 - Standard Test Methods for Water Vapor Transmission of Materials.
K. NAIMA National Insulation Standards.

1.4 SUBMITTALS FOR REVIEW
A. Submit under provisions of Division 1 General Requirements.
B. Product Data: Provide product description, thermal characteristics, list of materials and thickness for equipment scheduled.

1.5 QUALITY ASSURANCE
A. Applicator Qualifications: Company specializing in performing the work of this section with minimum three years' experience.

1.6 REGULATORY REQUIREMENTS
A. Materials: Flame spread/smoke developed rating of 25/50 in accordance with ASTM E84.
B. Conform to 2015 International Mechanical Code and 2018 International Energy Conservation Code with all amendments.

1.7 DELIVERY, STORAGE, AND PROTECTION
A. Deliver, store, protect and handle products to site under provisions of Division 1 General Requirements.
B. Accept materials on site in original factory packaging, labeled with manufacturer's identification, including product density and thickness.
C. Protect insulation from weather and construction traffic, dirt, water, chemical, and mechanical damage, by storing in original wrapping.

1.8 ENVIRONMENTAL REQUIREMENTS

A. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics, and insulation cements.
B. Maintain temperature during and after installation for minimum period of 24 hours.

PART 2 – PRODUCTS

2.1 GLASS FIBER, RIGID

A. Manufacturer:
   1. Owens Corning.
   2. Knauf.
   3. Pittsburgh Corning.
   4. Approved Equal.
B. Insulation: ASTM C612; rigid, noncombustible.
   1. 'K' ('Ksi') Value: ASTM C177 or ASTM C518, 0.24 at 75 degrees F.
   2. Maximum Service Temperature: 450 degrees F.
   3. Maximum Moisture Absorption: 0.1 percent by volume.
   4. Density: 2.0 lb./cu. ft.
C. Vapor Barrier Jacket:
   1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film.
   2. Moisture vapor transmission: ASTM E96; 0.02 perm.
   3. Secure with self-sealing longitudinal laps and butt strips.
   4. Secure with outward clinch expanding staples and vapor barrier mastic.
D. Facing: 1 inch galvanized steel hexagonal wire mesh stitched on one face of insulation.
E. Vapor Barrier Lap Adhesive:
   1. Compatible with insulation.
F. Insulating Cement/Mastic:
   1. ASTM C195; hydraulic setting on mineral wool.

2.2 JACKETS

A. Canvas Jacket: UL listed.
   1. Fabric: ASTM C921, 6 oz./sq. yd., plain weave cotton treated with dilute fire-retardant lagging adhesive.
   2. Lagging Adhesive:
      a. Compatible with insulation.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Verify that equipment has been tested before applying insulation materials.
B. Verify that surfaces are clean and dry, with foreign material removed.

3.2 INSTALLATION

A. Factory Insulated Equipment: Do not insulate.
B. Exposed Equipment: Locate insulation and cover seams in least visible locations.
C. Apply insulation close to equipment by grooving, scoring, and beveling insulation. Fasten insulation to equipment with studs, pins, clips, adhesive, wires, or bands.
D. Fill joints, cracks, seams, and depressions with bedding compound to form smooth surface. On cold equipment, use vapor barrier cement.
E. Insulated all equipment containing fluids above and below ambient temperature: Insulate entire system.

F. Fiber glass insulated equipment containing fluids below ambient temperature: Provide vapor barrier jackets, factory-applied or field-applied. Finish with glass cloth and vapor barrier adhesive.
G. Insulate flanges, fittings, valves and unions on all hot equipment.
H. Fiber glass insulated equipment containing fluids above ambient temperature: Provide standard jackets, with or without vapor barrier, factory-applied or field-applied. Finish with glass cloth and adhesive.
I. Finish insulation at supports, protrusions, and interruptions.
J. Cover glass fiber insulation with metal mesh and finish with heavy coat of insulating cement.
K. Nameplates and ASME Stamps: Bevel and seal insulation around; do not insulate over.
L. Equipment Requiring Access for Maintenance, Repair, or Cleaning: Install insulation so it can be easily removed and replaced without damage.

3.3 SCHEDULES

A. Heating, Cooling and Heating/Cooling Systems:
   1. Air Separators: 1" thick - glass fiber rigid.
   2. Expansion Tanks: 1" thick - glass fiber rigid.
   3. Hot, Chilled, and Hot/Chilled Water Pump Bodies: Removable two-piece molded polystyrene.
   4. Chiller Bundle Heads: 1” thick – removable polystyrene.

END OF SECTION

SECTION 15290

DUCTWORK INSULATION

PART 1 – GENERAL

1.1 WORK INCLUDED
A. Ductwork insulation.
B. Duct liner.
C. Insulation jackets.

1.2 RELATED WORK
A. Section 15190 - Mechanical Identification.
B. Section 15890 - Ductwork.

1.3 REFERENCES
A. ASTM C518 - Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
B. ASTM C553 - Mineral Fiber Blanket and Felt Insulation.
C. ASTM C612 - Mineral Fiber Block and Board Thermal Insulation.
D. ASTM E84 - Surface Burning Characteristics of Building Materials.
E. ASTM E96 - Water Vapor Transmission of Materials.
F. SMACNA - HVAC Duct Construction Standards - Metal and Flexible.

1.4 SUBMITTALS
A. Submit under provisions of Division 1 General Requirements.
B. Product Data: Provide product description, list of materials and thickness for each service and locations.
C. Contractor shall review all shop drawings prior to submitting them for Architect/Engineer's review. Contractor shall stamp each shop drawing to certify that he has reviewed it. Engineer will not check any shop drawings that contractor has not stamped with his review certification.

1.5 REGULATORY REQUIREMENTS
A. Conform to 2015 International Mechanical Code and 2018 International Energy Conservation Code with all amendments.

1.6 QUALITY ASSURANCE
A. Materials: Flame spread/smoke developed rating of 25/50 in accordance with ASTM E84.

1.7 QUALIFICATIONS
A. Applicator: Company specializing in performing the work of this Section with minimum three years’ experience.

1.8 DELIVERY, STORAGE AND HANDLING
A. Deliver, store, protect and handle products to site under provisions of Division 1 General Requirements.
B. Deliver materials to site in original factory packaging, labeled with manufacturer's density and thickness.
C. Contractor shall store all materials shipped to the site in a protected area. If material is stored outside of the building it must be stored off the ground a minimum of 6 inches set on 6 x 6 planks and/or wood pallets. All material must be completely covered with waterproof tarps or visqueen. All ductwork will have the ends closed to keep out dirt and other debris. No equipment will be allowed to be stored on the site unless it is sitting on wood planks and completely protected with weatherproof covers.

1.9 ENVIRONMENTAL REQUIREMENTS
A. Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics and insulation cements.

PART 2 – PRODUCTS

2.1 GLASS FIBER, FLEXIBLE DUCT WRAP (TYPE A)

A. Acceptable Manufacturers:
   1. Owens Corning Corp.
   2. CertainTeed Corp.
   3. Knauf Fiberglass.
   4. Manville.

B. Insulation: ASTM C553; flexible, noncombustible blanket.
   1. R Value: ASTM C518, 5.7 at 75-degrees F.
   2. Maximum Service Temperature: 250-degrees F.
   3. Maximum Moisture Absorption: 0.20 percent by volume.
   4. Density: 1.0 lb./cu. ft.
   5. Thickness: 1½-inch.

C. Vapor Barrier Jacket:
   1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film.
   2. Moisture Vapor Transmission: ASTM E96; 0.04 perm.
   3. Secure with pressure sensitive tape.

D. Vapor Barrier Tape:
   1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure sensitive rubber-based adhesive.

E. Tie Wire: Annealed steel, 16-gauge.

2.2 GLASS FIBER, RIGID DUCT WRAP (TYPE B)

A. Acceptable Manufacturers:
   1. Owens Corning Corp.
   2. CertainTeed Corp.
   3. Knauf Fiberglass.
   4. Manville.

B. Insulation: ASTM C612; rigid, noncombustible board with ASJ facing and ASJ tape.
   1. K Value: ASTM C518, 0.23 at 75 degrees F.
   2. Maximum Service Temperature: 250 degrees F.
   3. Maximum Moisture Absorption: 0.20 percent by volume.
   4. Density: 3.0 lb./cu. ft.
   5. Thickness: 2-inch.

C. Vapor Barrier Jacket:
   1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film.
   2. Moisture Vapor Transmission: ASTM E96; 0.04 perm.
   3. Secure with pressure sensitive tape.

D. Vapor Barrier Tape:
   1. Kraft paper reinforced with glass fiber yarn and bonded to aluminized film, with pressure sensitive rubber-based adhesive.

2.3 GLASS FIBER DUCT LINER, FLEXIBLE (TYPE C)

A. Acceptable Manufacturers:
   1. Owens Corning Corp.
   2. Knauf Fiberglass.
   3. Manville.
   4. Certain Teed Corp.

B. Insulation: ASTM C553; flexible, noncombustible blanket.
   1. K Value: ASTM C518, 0.27 at 75 degrees F.
   2. Maximum Service Temperature: 250 degrees F.
   3. Density: 3.0 lb./cu. ft.
   4. EPA registered anti-microbial coating on air side.
   5. Maximum Velocity on Coated Air Side: 4,000 ft/min.

C. Adhesive:
   1. Waterproof fire-retardant type.
D. Mechanical Fasteners: Galvanized steel, self-adhesive pad or impact applied with press on head. Install in accordance with the requirements of SMACNA Standards. Compression of linear surface not to exceed 10% of thickness.
E. Liner shall be attached to sheet metal using adhesive covering 90% of the metal surface.
F. Coat edge of upstream end of liner with adhesive.

OCTAVE BAND CENTER FREQUENCY						
THICKNESS	125	250	500	2000	4000	5000
1 Inch	0.09	0.19	0.48	0.65	0.83	0.9
2 Inch	0.22	0.47	0.76	0.89	0.91	0.95

2.4 HIGH TEMPERATURE GLASS FIBER, FLEXIBLE DUCT WRAP (TYPE D)

A. Acceptable Manufacturers:
   1. CertainTeed Corp.
   2. Thermal Ceramics.
   3. 3M.
B. Insulation: UL1978, ASTM E-119, (2) layers @ 1.5” thick high temperature glass fiber blanket, completely encapsulated in a UL Classified Aluminum foil, fiberglass reinforced scrim, to achieve a two-hour fire rating. Insulation to provide zero clearance to combustible.
C. Secure insulation with stainless steel banding.

2.5 JACKET

A. Aluminum:
   1. Thickness: 0.016-inch sheet.
   2. Finish: Embossed.
   3. Joining: Longitudinal slip joints and 2-lap joints.
   4. Fittings: 0.016-inch-thick die shaped fitting covers with factory attached protective liner.
   5. Metal Jacket Bands: 3/8-inch-wide; 0.010-inch-thick stainless steel.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Verify that ductwork has been tested before applying insulation materials.
B. Verify that surfaces are clean, foreign material removed and dry.

3.2 INSTALLATION

A. Install materials in accordance with manufacturer's instructions.
B. Insulated ductwork conveying air below ambient temperature:
   1. Provide insulation with vapor barrier jackets.
   2. Finish with tape and vapor barrier jacket.
   3. Continue insulation through walls, sleeves, hangers and other duct penetrations.
   4. Insulate entire system including fittings, joints, flanges, fire dampers, flexible connections and expansion joints.
C. Insulated ductwork conveying air above ambient temperature:
   1. Provide with standard vapor barrier jacket.
   2. Insulate fittings and joints. Where service access is required, bevel and seal ends of insulation.
D. External Duct Insulation Application:
   1. Secure insulation with vapor barrier with wires and seal jacket joints with vapor barrier adhesive or tape to match jacket; vapor tight.
   2. Install without sag on underside of ductwork. Use adhesive and mechanical fasteners where necessary to prevent sagging. Lift ductwork off trapeze hangers and insert spacers.
   3. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive.

4. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.
5. Supply and return air ductwork routed on exterior roof of building shall be internally and externally insulated. Provide exterior jacket over exterior insulation as indicated above. Provide roof curb at roof penetration.
6. Exterior Applications: Provide vapor barrier jacket. Insulate fittings and joints with insulation of like materials and thickness as adjoining ductwork and finish with glass mesh reinforced vapor barrier cement. Cover with jacket with seams located on bottom side of horizontal ductwork.

E. Duct and Plenum Liner Applications:
1. Adhere insulation with adhesive for 90 percent coverage.
2. Secure insulation with mechanical liner fasteners. Refer to SMACNA Standards for spacing.
3. Seal and smooth joints.
4. Seal liner surface penetrations with adhesive.
5. Duct dimensions indicated are net inside dimensions required for air flow. Increase duct size to allow for insulation thickness.

F. All insulation shall be installed neatly in a workman like manner in strict accordance with manufacturer's instructions.

3.3 TOLERANCE

A. Substituted insulation materials shall provide thermal resistance within 10 percent at normal conditions, as materials indicated.

3.4 GLASS FIBER DUCTWORK INSULATION SCHEDULE

TYPE DUCTWORK	THICKNESS INCHES	TYPE
All low and medium pressure rectangular supply and return ductwork	1”	C
Relief and transfer ducts	1”	C
Exhaust ducts	1”	C
Outdoor air intake ductwork/plenums	2”	B
All concealed round low and medium pressure rectangular supply and return ducts	1-1/2”	A
All ductwork located in exterior of building or unconditioned duct/attic space, supply and return.	1” 3”	C B
Kitchen Hood	(2) 1-1/2”	D

*Provide aluminum jacket for all ductwork located in the unconditioned mechanical chase.

**All exposed round supply air ductwork in the gymnasium to be uninsulated.

END OF SECTION

SECTION 15310

FIRE PROTECTION PIPING

PART 1 - GENERAL

1.1 SECTION INCLUDES
A. Pipe, fittings, valves, and connections for sprinkler systems.

1.2 RELATED SECTIONS
A. Section 15140 - Supports and anchors.
B. Section 15190 - Mechanical Identification: Piping identification.
C. Section 15325 - Sprinkler Systems: Sprinkler systems design.

1.3 REFERENCES
A. ASME B16.1 - Cast Iron Pipe Flanges and Flanged Fittings, Class 25, 125, 250, and 800.
B. ASME B16.3 - Malleable Iron Threaded Fittings, Class 150 and 300.
C. ASME B16.4 - Cast Iron Threaded Fittings, Class 125 and 250.
D. ASME B16.5 - Pipe Flanges and Flanged Fittings.
E. ASTM A135 - Electric Resistance Welded Steel Pipe.
F. ASTM A47 - Malleable Iron Castings.
G. ASTM A53 - Pipe, Steel, Black and Hot Dipped, Zinc coated Welded and Seamless.
H. AWS D10.9 - Specifications for Qualification of Welding Procedures and Welders for Piping and Tubing.
I. NFPA 13 - Installation of Sprinkler Systems.
J. NFPA 25 - Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems.
K. International Building Code, IBC (2015 Edition).
L. International Fire Code, IFC (2015 Edition).

1.4 SUBMITTALS FOR REVIEW
A. Submit under provision of Division 1 General Requirements.
B. Product Data: Provide manufacturers catalog information. Indicate valve data and ratings.
C. Shop Drawings: Indicate pipe materials used, jointing methods, supports, floor and wall penetration seals. Indicate installation, layout, weights, mounting and support details, and piping connections. Provide complete 1/8-inch scale drawings.
D. Provide additional sprinkler heads as required for complete coverage of entire building and coordination with architectural reflected ceiling plans.
E. CONTRACTOR SHALL REVIEW ALL SUBMITTALS PRIOR TO SUBMITTING THEM FOR THE ARCHITECT/ENGINEER'S REVIEW. CONTRACTOR SHALL STAMP EACH DRAWING AND EACH PIECE OF PRODUCT DATA TO CERTIFY THAT HE HAS REVIEWED IT. ARCHITECT/ENGINEER WILL NOT REVIEW ANY SUBMITTAL THAT CONTRACTOR HAS NOT STAMPED WITH HIS REVIEW CERTIFICATION. CONTRACTOR SHALL PROVIDE A LIST OF ITEMS SUBMITTED AT THE BEGINNING OF EACH SUBMTTAL. NO OLD OR OBSOLETE SUBMITTAL DOCUMENTATION WILL BE ACCEPTED.

1.5 SUBMITTALS AT PROJECT CLOSEOUT
A. Submit under provisions of Division 1 General Requirements.
B. Project Record Documents: Record actual locations of components and tag numbering.
C. Operation and Maintenance Data: Include installation instructions and spare parts lists.

1.6 QUALITY ASSURANCE
A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section.
B. Installer Qualifications: Company specializing in performing the work of this section with minimum 5 years' experience.

1.7 REGULATORY REQUIREMENTS
A. Conform to UL and FM.
B. Sprinkler Systems: Conform work to NFPA 13, NFPA 25, IFC 2015, and AHJ.

C. Welding Materials and Procedures: Conform to ASME Code.
D. Fittings and Valves: Bear UL and FM label or marking. Provide manufacturer's name and pressure rating marked on fitting or valve body.
E. Products Requiring Electrical Connection: UL and FM listed and classified as suitable for the purpose specified and indicated.

1.8 DELIVERY, STORAGE, AND PROTECTION

A. Deliver, store, protect and handle products to site under provisions of Division 1 General Requirements.
B. Deliver and store valves in shipping containers, with labeling in place.
C. Provide temporary protective coating on cast iron and steel valves.
D. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

PART 2 - PRODUCTS

2.1 ABOVE GROUND PIPING

A. Pipe 1½-Inch and Smaller: ASTM A53 or A135, Schedule 40, approved for fire protection service; Dyna-Thread 40 or Super-Flow 40 are acceptable equals. Schedule 10/thin wall not allowed. Joints: Threaded. Fittings: Cast iron or malleable iron listed in NFPA 13 for fire protection service.
B. Pipe 2-Inches and Larger: ASTM A53 or A135, Schedule 40, cut or roll grooved or Schedule 10 roll grooved only. Joints: Ductile iron gasketed grooved (0-degree deflection) rigid couplings. Fittings: Ductile iron grooved. Weld-O-Lets allowed on Schedule 40, or on Schedule 10, when performed in a certified fabrication shop. 'Hooker' or 'Fit' fittings are not permitted.
    1. Acceptable Manufacturers:
        a. Victaulic Co.
        b. Anvil International.
        c. Grinnell Corp.
C. Cast Iron Pipe: ANSI/AWWA C151.
    1. Fittings: ANSI/AWWA C110, standard thickness.
    2. Joints: ANSI/AWWA C111, flanged with rubber gasket.
    3. Mechanical Grooved Couplings: Malleable iron housing clamps to engage and lock, 'C' shaped composition sealing gasket, steel bolts, nuts and washers; galvanized for galvanized pipe.

2.2 PIPE HANGERS AND SUPPORTS

A. Conform to the more stringent of NFPA 13 and Section 15140 requirements.
B. Hangers for Pipe Sizes ½ to 1½-Inch: Malleable iron, adjustable swivel, split ring.
C. Hangers for Pipe Sizes 2 Inches and Over: Carbon steel, adjustable, clevis.
D. Wall Support for Pipe Sizes to 3-Inches: Cast iron hook.
E. Wall Support for Pipe Sizes 4-Inches and Over: Welded steel bracket and wrought steel clamp.
F. Vertical Support: Steel riser clamp.
G. Floor Support: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
H. Refer to Section 15140 for spacing and additional requirements.

2.3 GATE VALVES

A. Up to and including 2 Inches:
    1. Manufacturers:
        a. Nibco Valve Model T-104-0.
        b. Matco-Norca Model 501.
    2. 175 psi WOG bronze body, bronze trim, rising stem, handwheel, inside screw single wedge disc, threaded ends, UL and FM listed.

B. Over 2-Inches:
   1. Manufacturers:
      a. Nibco Valve Model F-607-OTS.
      b. Milwaukee Model F-2885-FP
      c. Watts Model 408-OSYRW – Lead Free
   2. 175 psi WOG iron body, bronze trim, rising stem handwheel, OS&Y, single wedge, flanged ends, UL and FM listed.

2.4 CHECK VALVES

A. Up to and including 2-Inches:
   1. Manufacturers:
      a. Nibco Valve Model KT-403-W.
   2. 175 psi WOG bronze body and swing disc, rubber seat, threaded ends, UL and FM listed.
B. Over 2 Inches:
   1. Manufacturers:
      a. Nibco Valve Model F-908-W.
      b. Milwaukee 2974-FP
      c. Kennedy Valve Model 1126
      d. Victaulic Model 717 – (Model does not have flanged ends).
   2. 175 psi WOG, Iron body, bronze trim, swing disc, renewable disc and seat, flanged ends, UL and FM listed.

2.5 DRAIN VALVES

A. Manufacturers:
   1. Milwaukee Valve.
   2. Nibco Valve.
   3. Kennedy Valve.
   4. Seco Co.
B. Bronze compression with hose thread nipple and cap.
C. Brass with cap and chain, ¾-inch hose thread.

PART 3 - EXECUTION

3.1 PREPARATION

A. Ream pipe and tube ends. Remove burrs.
B. Remove scale and foreign material, from inside and outside, before assembly.
C. Prepare piping connections to equipment with flanges or unions.

3.2 INSTALLATION

A. Install piping in accordance with NFPA 13 for sprinkler systems.
B. Route piping in orderly manner, plumb and parallel to building structure. Maintain gradient.
C. Install piping to conserve building space, to not interfere with use of space and other work.
D. Group piping whenever practical at common elevations.
E. Sleeve pipes passing through partitions, walls, and floors.
F. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
G. Slope piping and arrange systems to drain at low points. Use eccentric reducers to maintain top of pipe level.
H. Do not penetrate building structural members unless indicated.
I. Provide sleeves when penetrating footings, floors and walls. Seal pipe and sleeve penetrations to achieve fire resistance equivalent to fire separation required.
J. When installing more than one piping system material, ensure system components are compatible and joined to ensure the integrity of the system. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.

K. Die cut threaded joints with full cut standard taper pipe threads with red lead and linseed oil or other non-toxic joint compound applied to male threads only.
L. Install valves with stems upright or horizontal, not inverted. Remove protective coatings prior to installation.
M. Provide drain valves at main shut-off valves, low points of piping and apparatus.
N. Install valve supervisory switches on each gate or globe valve.
O. Provide auxiliary drains with ¾-inch capped hose threads at all low points which cannot be drained to shut off valve.
P. Provide air relief valves at all system high points or where air may become trapped within the system.
Q. Provide inspector's test station at most remote area of each floor or zone with gate or globe valve and site glass piped to grade.

END OF SECTION

SECTION 15320

FIRE PUMPS

PART 1 - GENERAL

1.1 SECTION INCLUDES
A. In-line fire pump.
B. Fire pump motor.
C. Electric jockey pump.
D. Controllers.

1.2 RELATED SECTIONS
A. Section 15310 - Fire Protection Piping.
B. Section 15325 - Sprinkler Systems.

1.3 REFERENCES
A. FM - Factory Mutual System - Approval Guide.
B. NEMA MG-1 - Motors and Generators.
C. NEMA 250 - Enclosures for Electrical Equipment (1000 Volt Maximum).
D. NFPA 13 - Installation of Sprinkler Systems.
E. NFPA 20 - Installation of Centrifugal Fire Pumps (2003 Edition).
F. NFPA 70 - National Electrical Code.
G. UL - Fire Protection Equipment Directory.
H. UL 448 - Pumps for Fire Protection Service.
I. UL 1478 - Fire Pump Relief Valves.

1.4 DESIGN REQUIREMENTS
A. Conform to NFPA 13.

1.5 PERFORMANCE REQUIREMENTS
A. Conform to NFPA 13.

1.6 SUBMITTALS FOR REVIEW
A. Shop Drawings, Product Data and Samples: Refer to Division 1 General Requirements for procedures for submittals.
B. Product Data: Provide manufacturers literature including general assembly, pump curves showing performance characteristics with pump and system, operating point indicated, NPSH curve, controls, wiring diagrams, and service connections.
C. Shop Drawings: Indicate layout, general assembly, components, dimensions, weights, clearances, and methods of assembly.

1.7 SUBMITTALS FOR INFORMATION
A. Contract Closeout: Refer to Division 1 General Requirements for procedures for submittals.
B. Test Reports: Indicate results of hydrostatic test and field acceptance tests performed in accordance with NFPA 20.
C. Manufacturer's Instructions: Indicate support details, connection requirements, for fire pump system.

1.8 OPERATION AND MAINTENANCE DATA
A. Operation and Maintenance Data. Refer to Division 1 General Requirements for procedures for submittals.
B. Warranties and Bonds: Refer to Division 1 General Requirements for procedures for submittals.
C. Project Record Documents: Record actual locations of components and accessories.
D. Certificates: Certify that fire pumps meet or exceed specified requirements at specified operating conditions and that the installation complies with regulatory requirements. Submit summary and results of shop tests performed in accordance with NFPA 20.
E. Operation Data: Include manufacturer’s instructions, start-up data, trouble-shooting check lists, for pumps, drivers, and controllers.
F. Maintenance Data: Include manufacturers literature, cleaning procedures, replacement parts lists, and repair data for pumps, drivers, and controllers.
G. Refer to Division 1 General Requirements and Part 3 of this Specifications for Execution for Owner Training Requirements.

1.9 QUALITY ASSURANCE

A. Perform Work in accordance with NFPA 20. Maintain one copy on site.
B. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum five years documented experience.
C. Installer Qualifications: Company specializing in performing the work of this section with minimum five years documented experience.
D. Submit reports on system tests from manufacturer's authorized agent in accordance with Division 1 General Requirements.

1.10 REGULATORY REQUIREMENTS

A. Conform to UL and FM.
B. Perform work in accordance with NFPA 20.
C. Conform to NFPA 20 for installation and testing of fire pumps, drivers, and controllers.
D. Provide certificate of compliance from authority have jurisdiction indicating approval of field acceptance tests.
E. Equipment and Components: Bear UL and FM label or marking.
F. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

1.11 DELIVERY, STORAGE, AND PROTECTION

A. Accept fire pumps and components on site in factory packing. Inspect for damage. Comply with manufacturers rigging and installation instructions.
B. Protect fire pumps and components from physical damage including effects of weather, water, and construction debris.
C. Provide temporary inlet and outlet caps and maintain in place until installation.

1.12 MAINTENANCE SERVICE

A. Provide service and maintenance of fire pump, driver, and controller for one year from date of Substantial Completion.

1.13 EXTRA MATERIALS

A. Provide one set of gaskets and seals for each pump type and model supplied.

PART 2 - PRODUCTS

2.1 MANUFACTURERS IN-LINE FIRE PUMPS

A. Patterson Pump Co – VIP Vertical In-Line 5 x 3.
B. Other Acceptable Manufacturers:
   1. Aurora Pump Co.
   2. Peerless Pump Co.
   3. A-C/ITT Pump Co.

2.2 IN-LINE PUMPS

A. Type: UL 448 in-line vertical, centrifugal, direct connected 250 psig maximum working pressure, with 125# ANSI flanges.
B. Casing: Cast iron, rated for 250 psi working pressure, suction and discharge gage, wear rings, drain plug, inlet and outlet pressure gauge taps, flanged suction, and discharge.
C. Impellers: Bronze, fully enclosed, keyed to shaft or secured with lock nut.
D. Shaft: Stainless steel or carbon steel with bronze or stainless-steel sleeve through seal chamber.
E. Baseplate: Cast iron or fabricated steel with bolt holes.
F. Performance: (Note: Fire Sprinkler Contractor is responsible for final sizing and selection of fire pump.)
   1. Flow: 500 GPM at 50 psi developed with 30 psi suction pressure.
   2. Motor: 25 hp, 460-volt, three phase, 60 Hz.

Note: Final size of Fire Pump is to be determined by Fire Protection Contractor, based on their system design calculations.

2.3 FIRE PUMP ACCESSORIES

A. Eccentric suction reducer and OS & Y gate valve on suction and discharge side of pump.
B. Concentric increaser and check valve on pump discharge.
C. Liquid filled, 4½-inch diameter suction and discharge pressure gage mounted on board attached to pump, with snubber, valve cock and lever handle.
D. Flush mounted, polish brass hose valve outlet with four (4) 2½-inch brass hose gate valve, faceplate, caps, and chains. Refer to Section 21 13 13 for additional requirements.

2.4 MANUFACTURERS - CONTROLLERS

A. Patterson Pump Co.
B. Master Control Systems.
C. Firetrol.
D. A-C/ITT Pump Co.
E. No Substitutions.

2.5 ELECTRIC MOTOR DRIVE

A. Motor: Squirrel cage induction type; in open drip proof NEMA MG-1 enclosure, 3600 rpm.
B. Controller: Service entrance rated type with electronic soft starting and integral fused disconnect switch and transfer switch in NEMA 12 (13 gauge) enclosure, including the following:
   1. Disconnect Switch: Externally operable, quick break type.
   2. Circuit Breaker: Size to NFPA 20, minimum 100,000 amperes interrupting capacity.
   3. Motor Starter: Energized automatically through pressure switch or manually by externally operable handle.
   4. Pressure Switch: Set to cut in at 85 psi.
   5. Running Period Timer: Keeps motor in operation when started automatically, for a minimum of seven minutes.
   6. Pilot Lamps: Indicates circuit breaker closed and power available, phase reversal, A.C. failure, pump run, transfer switch normal/emergency and isolation switch open.
   7. Alarm Relay: Energizes panel mounted alarm to indicate circuit breaker open or power failure.
   8. Switch Relay: For remote start.
   9. Manual Selector Station: On enclosure marked "Automatic" and "Non-Automatic."
   10. Integral electronic pressure recorder with digital read-out and memory.
   11. Remote contacts: Provide 10-amp, 120 volt contacts for pump running, power failure, phase reversal, transfer switch normal.
   12. Built-in alarm system.
   13. Transfer switch, size to NFPA-20, minimum 22,000 amperes interrupting capacity.
   14. Controller and transfer switch shall meet all requirements of the 1999 edition of NFPA-20.
C. Electrical Characteristics:
   1. 25 hp.
   2. 460 volts, three phase, 60 Hz.

2.6 PRESSURE BOOSTER (JOCKEY) PUMP

A. Manufacturer: Patterson Pump Co.
B. Other acceptable manufacturers offering equivalent products.
   1. Patterson Pump Co.
   2. Peerless Pump Co.
   3. A-C/ITT Pump Co.
C. Electrically operated, stainless steel, multi-stage (12 stage) horizontal type with drain plug, pressure switch, relief valve, pressure gauge, and standard open drip-proof horizontal motor.
D. Control by automatic jockey pump controller with combination full voltage starter and fused disconnect, minimum run timer to start pump on pressure drop in system and stay in operation for minimum period of time, power “on” and pump “run” pilot lights, and hand-off-auto selector switch. Fire pump shall start automatically on further pressure drop or on jockey pump failure. Controller to have integral disconnect switch and indicating pilot lights. Control shall include an adjustable pressure switch with gauge cock.

E. Performance: 5 GPM @ 70 psi.
F. Electrical Characteristics:
   1. 0.75 hp, 3450 RPM.
   2. 460 volts, three phase, 60 Hz.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with NFPA 20.
B. Provide access space around pumps for service; no less than minimum as recommended by manufacturer.
C. Install piping in accordance with Section 21 13 00. Increase from line size with long radius increasing elbows. Support piping adjacent to pump such that no weight is carried on pump casings.
D. Provide drains for bases and seals, piped to and discharging into floor drains.
E. Provide for connection to electrical service.
F. Lubricate pumps before start-up.
G. Check, align, and certify pumps by qualified millwright prior to start-up.

3.2 FIELD QUALITY CONTROL

A. Testing: Fire Pump shall be Laboratory Tested with Certified Performance Test Curves furnished to the Architect/Engineer and the Insurance Authority at the time of Field Acceptance Tests. The Pump Manufacturer shall provide the services of a qualified Fire Protection Engineer (Member or Associate Member-SFPE) to perform the following services: living and traveling expenses shall be included for necessary travel to and from the construction site):
   1. Supervise and direct start-up and run-in of the motors, controllers, switchgear, and accessories.
   2. Arrange and conduct the final Field Acceptance Tests and provide all required test equipment, including Underwriter's Playpipes, Pitot, test gauges, tachometer, and clamp-on-ammeter. The Field Tests shall meet the requirements of the Insurance Authority.
   3. Simulate all controller fault conditions in the presence of the Owner's representative to assure proper function of all supervisory circuits and devices.
   4. Instruct the Owner's forces on the operation and maintenance procedure of the pumps and all equipment including supervisory controls during Field Test
B. Perform flow test on entire system in accordance with NFPA 20.
C. Require test to be witnessed by authority having jurisdiction and/or Architect/Engineer.

3.3 DEMONSTRATION AND INSTRUCTIONS

A. In accordance with Division 1 General Requirements.
B. At the completion of the project, the Installing Contractor shall provide training for the entire sprinkler system for Owner's staff. Training shall consist of two parts. Part One is a classroom situation which describes the equipment's operation, maintenance, and repair requirements. Part Two will be on-site (hands-on) training which will show the location of all pumps, devices and the operation and maintenance of all controls, devices, etc. This training will be in addition to other training specified in the contract. Prior to commencement of training, Contractor shall provide Architect/Engineer with a schedule of dates, times, and agenda for each training session. This Contractor shall provide a minimum of four (4) hours of training for work installed under this section of the contract. Contractor shall furnish a minimum of six (6) equipment manuals, maintenance manuals and repair parts list for all equipment and systems reviewed.
C. Demonstrate automatic operation of system including verification of pressure switch set points.

END OF SECTION

SECTION 15325

SPRINKLER SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES
A. Wet pipe sprinkler system.
B. System design, installation, and certification.

1.2 RELATED SECTIONS
A. Section 15190 - Mechanical Identification.
B. Section 15310 – Fire Protection Piping.
C. Section 15430 - Plumbing Specialties

1.3 REFERENCES
A. NFPA 13 - Installation of Sprinkler Systems.
B. NFPA 25 - Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems.
C. FM - Factory Mutual Approval Guide.
D. NFPA 70 - National Electrical Code.
E. Screw Thread Connections:
   1. Comply with local fire department/marshal regulations for sizes, threading and arrangement of connections for fire department equipment to systems. Comply with NFPA 194 Standard for screw threads and gaskets for fire hose connections.
F. UL - Fire Resistance Directory.
G. UL 199 - Automatic Sprinklers.
H. UL 203 - Pipe Hanger Equipment for fire protection service.
I. UL 864 - Control units for fire protective signaling service.
J. International Building Code (IBC), 2015 Edition.
K. International Fire Code (IFC), 2015 Edition.

1.4 SYSTEM DESCRIPTION
A. Sprinkler system design is by Fire Sprinkler Contractor, and they are to be the “Engineer of Record” for the system.
B. Provide coverage for the entire building addition and sprinkler relocation areas as noted on the drawings. Provide system to NFPA 13 light hazard and ordinary hazard Group I occupancy requirements, as indicated on drawings.
C. Contractor Option: Utilize extended coverage type sprinkler heads at light hazard occupancy areas.
D. Determine volume and pressure of water supply by conducting independent water flow test with Village of Orland Park Water Department. Fire Protection Contractor is responsible to coordinate water flow test and to provide water flow test results to Architect, Engineer, and Owner.
E. Provide a 10% or 10 psi, whichever is greater, safety factor on all flow calculations.
F. Provide flush mounted polished brass or steel Storz fire department and fire pump test connections to meet requirements of Orland Park Fire Department.
G. Fire sprinkler contractor is responsible for final design, layout and hydraulic calculations for a complete approved sprinkler system.

1.5 FEES
A. Contractor to pay plan review fees to the Village of Orland Park Fire Department.

1.6 SUBMITTALS FOR REVIEW

A. Submit under provisions of Division 1 General Requirements.
B. Product Data: Provide data on sprinklers, valves, and specialties, including manufacturers catalog information. Submit performance ratings, rough-in details, weights, support requirements, and piping connections.
C. Shop Drawings:
   1. **SHOP DRAWINGS MUST BE COORDINATED WITH MECHANICAL, ELECTRICAL AND PLUMBING TRADES PRIOR TO SUBMISSION FOR REVIEW.**
   2. Submit preliminary 1/8" scale layout of finished ceiling areas indicating only sprinkler locations coordinated with ceiling installation.
   3. Indicate hydraulic calculations, detailed pipe layout, hangers and supports, sprinklers, components and accessories. Indicate system controls.
   4. Prepare submittal in accordance with NFPA-13 requirements.
D. Submit 1/8" scale shop drawings, product data and hydraulic calculations to authority having jurisdiction for approval. Submit proof of approval to Architect/Engineer.
E. CONTRACTOR SHALL REVIEW ALL SUBMITTALS PRIOR TO SUBMITTING THEM FOR THE ARCHITECT/ENGINEER'S REVIEW. CONTRACTOR SHALL STAMP EACH DRAWING AND EACH PIECE OF PRODUCT DATA TO CERTIFY THAT HE HAS REVIEWED IT. ARCHITECT/ENGINEER WILL NOT REVIEW ANY SUBMITTAL THAT CONTRACTOR HAS NOT STAMPED WITH HIS REVIEW CERTIFICATION. CONTRACTOR SHALL PROVIDE A LIST OF ITEMS SUBMITTED AT THE BEGINNING OF EACH SUBMTTAL. NO OLD OR OBSOLETE SUBMITTAL DOCUMENTATION WILL BE ACCEPTED.

1.7 SUBMITTALS AT PROJECT CLOSEOUT

A. Submit under provisions of Division 1 General Requirements.
B. Project Record Documents: Record actual locations of sprinklers and deviations of piping from drawings. Indicate drain and test locations.
C. Manufacturer's Certificate: Certify that system has been tested and meets or exceeds specified requirements.
D. Operation and Maintenance Data: Include components of system, servicing requirements, record drawings, inspection data, replacement part numbers and availability, and location and numbers of service depot.
E. Warranty: Submit manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.
F. Fire Protection Contractor is to provide the Owner with a copy of NFPA 25 per NFPA 25 Instructions Section. The copy of NFPA 25 shall remain on site with the Owner.
G. Refer to Part 3 - Execution of this section for Owner Training Requirements.

1.8 QUALITY ASSURANCE

A. Perform Work in accordance with NFPA 13. Maintain one copy on site.
B. Perform Work in accordance with NFPA 25. Maintain one copy on site.
C. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this Section with a minimum of 5 years documented experience.
D. Installer Qualifications: Company specializing in performing the work of this Section with minimum 5 years documented experience.
E. Design system under direct supervision of a Professional Engineer experienced in design of this Work.

1.9 REGULATORY REQUIREMENTS

A. Conform to UL and FM.
B. Perform Work in accordance with NFPA 13.
C. Perform Work in accordance with NFPA 25.
D. Equipment and Components: Bear UL and FM label or marking.
E. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

1.10 DELIVERY, STORAGE, AND PROTECTION

A. Deliver products to site under provisions of Division 1 General Requirements.
B. Store products in shipping containers and maintain in place until installation. Provide temporary inlet and outlet caps. Maintain caps in place until installation.

1.11 EXTRA MATERIALS

A. Provide four (4) extra sprinkler heads of each type installed within each system in accordance with NFPA 13. Each system with its own water service will be considered one (1) system. Where two or more risers are located in the same location, each riser is to have a separate cabinet with all required materials. Store in steel cabinet with baked enamel finish located at each system's risers.
B. Provide cabinet with sufficient space to accommodate all sprinkler heads and suitable wrenches for each sprinkler type.
C. Provide 100 spare face plates to Owner.
D. Refer to Division 1 General Requirements for additional requirements.

PART 2 - PRODUCTS

2.1 SPRINKLERS

A. Suspended Ceiling:
   1. Manufacturers:
      a. Tyco.
      b. Reliable Fire.
      c. Viking Corp.
      d. Substitutions: Not Permitted.
   2. Type: Concealed pendant type with matching clamp on or screw on escutcheon plate.
   3. Finish: Enamel, color white.
   4. Escutcheon Plate Finish: Enamel, color white.
   5. Fusible Link: Glass bulb or fusible link type temperature rated for specific area hazard or as designated on plans.

B. Exposed Area Type:
   1. Manufacturers:
      a. Tyco.
      b. Reliable Fire.
      c. Viking Corp.
      d. Substitutions: Not Permitted.
   2. Type: Standard upright or pendant type with wire guard; coordinate sprinkler type with structure and ductwork.
   3. Finish: Brass.
   4. Fusible Link: Glass bulb or fusible link type temperature rated for specific area hazard or as designated on plans.

C. Finished Area Sidewall Type:
   1. Manufacturers:
      a. Tyco.
      b. Reliable Fire.
      c. Viking Corp.
      d. Substitutions: Not Permitted.
   2. Type: Semi-recessed horizontal sidewall type with matching clamp on or screw on escutcheon plate.
   3. Head Finish: Enamel, color white.
   4. Fusible Link: Glass bulb or fusible link type temperature rated for specific area hazard.

D. Exposed Area Sidewall Type:
   1. Manufacturers:
      a. Tyco.
      b. Reliable Fire.
      c. Viking Corp.
      d. Substitutions: Not Permitted.
   2. Type: Horizontal sidewall type with wire guard.
   3. Head Finish: Brass.
   4. Fusible Link: Glass bulb or fusible link type temperature rated for specific area hazard.
E. Wire Guards:
   1. Provide wire guards on all exposed sprinkler heads unless otherwise indicated on the drawings.

2.2 PIPING SPECIALTIES

A. Water Flow Switch (FS): Paddle or vane type switch for mounting horizontal or vertical, rated 250 psi, with aluminum dust and moisture proof cover, adjustable time delay and two contacts rate 7.0 amp at 115-volt AC and 0.25 amp at 6-125-volt DC.
   1. Manufacturers:
      a. Potter VSR.
      b. Substitutions: Not permitted.
B. Valve Supervisory Switch (VSS):
   1. Acid treated cast aluminum housing, nickel-plated corrosion-resistant parts, two contacts rated 7.0 amp at 115-volt AC and 0.25 amp at G-125-volt DC, tamper proof cover activates alarm when removed and unit to indicate closed position.
   2. Manufacturers:
      a. Potter OSYSU.
      b. Substitutions: Not Permitted.
C. Fire Department Connection - FDC (Wall Type):
   1. Wall Type: Wall mounted with Storz connection. Contractor to verify exact type with local authorities.
   2. Outlet: 5-inch Storz with tread size to suit fire department hardware. Threaded polished brass or steel cap and chain of matching material and finish.
   3. Drain: ¾-inch automatic ball drip to grade.
   4. Label: “AUTO-SPRK” Fire Department Connection.
   5. Substitutions: Not Permitted.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with NFPA 13 and FM installation guide.
B. Install equipment in accordance with manufacturer’s instructions.
C. Place pipe runs to minimize obstruction to other work.
D. Place piping in concealed spaces above finished ceilings.
E. Center sprinklers in two directions in full or half section ceiling tile and provide piping offsets as required.
F. Apply masking tape or paper cover to ensure sprinkler heads, cover plates, and sprinkler escutcheons do not receive field paint finish. Remove after painting.
G. Flush entire piping system of foreign matter.
H. Hydrostatically test entire system.
I. Require test be witnessed by authority having jurisdiction, construction manager and Architect/Engineer.
J. Fire Protection Test shall be compliant to NFPA 25 and AHJ.
K. Provide 1-inch diameter nipple and 1-inch x 1/2 inch reducing fitting for each head; bushings are not permitted.
L. Mount supervisory switches on each sectional valve.

M. Install manual air vents at high points of sprinkler piping.
N. Install drain valves with hose thread connections and brass caps in piping at low points of sprinkler piping.
O. Identification: Apply signs to control, drain, test and alarm valves to identify their purpose and function.
    1. Provide lettering size and style selected by Architect/Engineer from NFPA's suggested guides.
P. Provide access and access panels for all valves and devices located above ceiling. Provide ceiling tile identification for locating valves and devices.
Q. All welding by certified welders.
R. Locate fire department connection with sufficient clearance from walls, obstructions or adjacent connections to allow full sing of fire department wrench handle.
S. Locate exterior alarm gong and visual strobe on building wall adjacent to fire department connection. Coordinate with Electrical.
T. Locate interior alarm going on building wall adjacent to sprinkler riser. Coordinate with electrical.
U. Flexible sprinkler connectors are not allowed.

3.2 FIELD QUALITY CONTROL

A. Hydrostatic Testing:
    1. After flushing system, test fire sprinkler piping hydrostatically for period of 2 hours at minimum 200 psi.
    2. Inspect system for leakage at joints.
    3. Measure hydrostatic pressure at low point of each system or zone being tested.
    4. The entire system (i.e., valves, sprinkler heads, flow switches, etc.) must be completely installed prior to performing tests in accordance with NFPA 13.
B. System Flushing:
    1. Contractor to flush water service prior to installation of backflow preventer provided by the Plumbing Contractor. If flushing occurs after backflow preventer installation, fire protection contractor to compensate plumbing contractor for testing and repairing backflow preventer.
    2. Contractor to flush sprinkler system.
    3. Request witness of flushing operations 48 hours in advance. Contact Construction Manager.
    4. Submit test reports in accordance with Division 1 General Requirements.
C. Repair or replace piping system to eliminate leakage in accordance with NFPA standards for "little or no leakage" and retest as specified to demonstrate compliance.
D. Submit test reports in accordance with Division 1 General Requirements.

3.3 OWNER TRAINING BY INSTALLING CONTRACTOR

A. At the completion of the project, the Installing Contractor shall provide training for the entire sprinkler system for Owner's staff. Training shall consist of two parts. Part One is a classroom situation which describes the equipment's operation, maintenance, and repair requirements. Part Two will be on-site (hands-on) training which will show the location of all devices and the operation and maintenance of all controls, devices, etc. This training will be in addition to other training specified in the contract. Prior to commencement of training, Contractor shall provide Architect/Engineer with a schedule of dates, times, and agenda for each training session. This Contractor shall provide a minimum of eight (8) hours of training for work installed under this section of the contract. Contractor shall furnish a minimum of eight (8) equipment manuals, maintenance manuals and repair parts list for all equipment and systems reviewed.

END OF SECTION

SECTION 15410

PLUMBING PIPING

PART 1 - GENERAL

1.1 SECTION INCLUDED

A. Pipe, pipe fittings, valves, and connections for piping systems.
   1. Sanitary sewer, drainage, and vent.
   2. Domestic water.
   3. Storm water.

B. Testing, adjusting, and balancing of domestic hot and domestic tempered water circulating system. Coordinate with Test and Balancing Contractor and Sections 17600 and 17800 provided under separate cover.

1.2 RELATED SECTIONS

A. Section 15135 – Gages and Meters.
B. Section 15140 – Supports and Anchors.
C. Section 15190 – Mechanical Identification.
D. Section 15260 – Piping Insulation.
E. Section 15430 – Plumbing Specialties.
F. Section 15440 – Plumbing Fixtures.
G. Section 15450 – Plumbing Equipment.
H. Section 16170 – Grounding and Bonding.
I. Section 16180 – Equipment Wiring.
J. Section 17600 – Sequence of Operations.
K. Section 17800 – Testing, Adjusting, and Balancing.
L. Division 16 Specifications – Equipment Wiring Systems: Electrical characteristics and wiring connections.

1.3 REFERENCES

A. ASME B16.1 - Cast Iron Pipe Flanges and Flanged Fittings Class 25, 125, 250 and 800.
B. ASME B16.3 - Malleable Iron Threaded Fittings.
C. ASME B16.4 - Cast Iron Threaded Fittings Class 125 and 250.
D. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings.
E. ASME B16.22 - Wrought Copper and Bronze Solder Joint Pressure Fittings.
F. ASME B16.23 - Cast Copper Alloy Solder Joint Drainage Fittings - DWV.
G. ASME B16.26 – Cast Bronze Fittings for Flared Copper Tubes.
H. ASME B31.1 - Power Piping.
I. ASME B31.9 – Building Service Piping.
J. ASME SEC IX - Welding and Brazing Qualifications.
K. ASTM A53 - Pipe, Steel, Black and Hot-Dipped Zinc Coated, Welded and Seamless.
L. ASTM A74 - Cast Iron Soil Pipe and Fittings.
M. ASTM B32 - Solder Metal.
N. ASTM B42 – Seamless Copper Pipe.
O. ASTM B88 - Seamless Copper Water Tube.
P. ASTM B306 - Copper Drainage Tube (DWV).
Q. ASTM C564 - Rubber Gaskets for Cast Iron Soil Pipe and Fittings.
R. ASTM E814 - Fire Tests of Through-Penetration Fire Stops.
S. ASTM F477 – Elastomer Seals (Gaskets) for Joining Plastic Pipe.
T. ASTM F708 - Design and Installation of Rigid Pipe Hangers.
U. AWS A5.8 - Brazing Filler Metal.
V. AWWA C105 - Polyethylene Encasement for Ductile Iron Piping for Water and Other Liquids.
W. AWWA C110 - Ductile - Iron and Gray - Iron Fittings 3 in. through 48 in., for Water and Other Liquids.
X. AWWA C111 - Rubber-Gasket Joints for Ductile Iron and Gray-Iron Pressure Pipe and Fittings.
Y. AWWA C151 - Ductile-Iron Pipe, Centrifugally Cast in Metal Molds or Sand-Lined Molds, for Water or Other Liquids.
Z. AWWA C651 - Disinfecting Water Mains.

AA. CISPI 301 - Cast Iron Soil Pipe and Fittings for Hubless Cast Iron Sanitary Systems.
BB. CISPI 310 - Joints for Hubless Cast Iron Sanitary Systems.
CC. MSS SP58 - Pipe Hangers and Supports - Materials, Design and Manufacturer.
DD. MSS SP69 - Pipe Hangers and Supports - Selection and Application.
EE. MSS SP-70 - Cast Iron Gate Valves, Flanged and Threaded Ends.
FF. MSS SP-71 - Cast Iron Swing Check Valves, Flanged and Threaded Ends.
GG. MSS SP-80 - Bronze Gate, Globe, Angle and Check Valves.
HH. MSS SP89 - Pipe Hangers and Supports - Fabrication and Installation Practices.
II. MSS SP-110 - Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends.
JJ. UL 1479 - Fire Tests of Through-Penetration Firestops.
KK. ASTM D-1784-11 – Standard Specifications for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds.

1.4 SUBMITTALS

A. Submit product data under provisions of Division 1 General Requirements.
B. Product Data: Provide data on pipe materials, pipe fittings, valves, and accessories. Provide manufacturers catalog information. Indicate valve data and ratings.
C. Manufacturer’s Certificate: Certify that products meet or exceed specified requirements.
D. Contractor shall review all shop drawings prior to submitting them for Architect/Engineer's review. Contractor shall stamp each shop drawing to certify that he has reviewed it. Engineer will not check any shop drawings that contractor has not stamped with his review certification.
E. Contractor shall review all shop drawings prior to submitting them for Architect/Engineer's review. Contractor shall stamp each shop drawing to certify that he has reviewed it. Engineer will not check any shop drawings that contractor has not stamped with his review certification. Identify all products that are to be reviewed in the submittal documents. Provide a list of all items to be reviewed at the beginning of the submittal documentation. No obsolete submittal documentation shall be accepted.
F. Submit preliminary valve chart indicating naming/location conventions along with piping shop drawings for preliminary approval.
G. Piping Shop Drawings.
    1. Submit 1/8-inch scale drawings for the piping systems, showing the pipe sizes, pipe material, location, elevations, invert elevations, slopes of horizontal runs, ejector basins, manholes, cleanouts, fittings, accessories, piping expansion devices, valves, meters, gauges, offsets, rises, drops, coordination amongst other trade contractors and connections.
    2. Piping Shop drawings shall be prepared with building architectural layout in the back-ground.
    3. REPRODUCTIONS OF THE CONTRACT DOCUMENTS BY ANY MEANS (ELECTRONIC, MAGNETIC STORAGE MEDIA, PHOTOGRAPHIC, ETC.) WILL NOT BE ACCEPTED FOR REVIEW.
    4. CAD (Computer Aided Design) drawing files in AutoCAD Release 2010 *.DWG file format, will be made available to the Awarded Plumbing Contractor for a nominal processing fee of $250.00. This is to cover O'Higgins and Arnold LLC’s administrative processing costs of making such files available to the Plumbing Contractor. The Contractor must agree to sign an indemnity waiver eliminating O'Higgins and Arnold LLC from any inaccuracies or harm caused by using these files. This service does not fall under the restrictions of Paragraph No. 3, above.
    5. CONTRACTOR SHALL REVIEW ALL SUBMITTALS PRIOR TO SUBMITTING THEM FOR THE ARCHITECT/ENGINEER’S REVIEW. CONTRACTOR SHALL STAMP EACH DRAWING AND EACH PIECE OF PRODUCT DATA TO CERTIFY THAT HE HAS REVIEWED IT. ARCHITECT/ENGINEER WILL NOT REVIEW ANY SUBMITTAL THAT CONTRACTOR HAS NOT STAMPED WITH HIS REVIEW CERTIFICATION. CONTRACTOR SHALL PROVIDE A LIST OF ITEMS SUBMITTED AT THE BEGINNING OF EACH SUBMTTAL. NO OLD OR OBSOLETE SUBMITTAL DOCUMENTATION WILL BE ACCEPTED.

6. Submit preliminary valve chart indicating naming/location conventions along with piping shop drawings for preliminary approval.

1.5 PROJECT RECORD DOCUMENTS

A. Submit project record documents under provision of Division 1 General Requirements.
   1. Specification Section – Execution Requirements, Closeout Procedures.
B. Project Record Documents: Record actual locations of piping, valves, equipment, cleanouts, backflow preventers, drains, wall hydrants, etc. Submit final valve chart. Comply with Section 15190: Mechanical Identification and identification details on the drawings.
C. Operation and Maintenance Data: Submit spare parts list, exploded assembly views and recommended maintenance intervals.

1.6 OPERATION AND MAINTENANCE DATA

A. Submit under provisions of Division 1 General Requirements.
B. Maintenance Data: Include components of system, servicing requirements, record drawings, inspection data, replacement parts numbers and availability and location and numbers of service depot.
C. Refer to Part 3. - EXECUTION of this section for Owner training requirements.

1.7 QUALITY ASSURANCE

A. Perform Work in accordance with State of Illinois Plumbing Code, 2014. Maintain one copy on site.
   1. Provide reports of inspections by State of Illinois Plumbing inspectors in accordance with Division 1 General Requirements.
B. Valves: Manufacturer's name and pressure rating marked on valve body.
C. Welding Materials and Procedures: Conform to ASME SEC IX and applicable state labor regulations.
D. Welders Certification: In accordance with ASME SEC IX or ANSI/AWS D1.1.
E. Identify pipe with marking including size, ASTM material classification, ASTM specification, potable water certification, water pressure rating.
F. Maintain one copy of each document on site.
G. All products to comply with State of Illinois Plumbing Code requirements.
H. Underwriters Laboratory (UL):
   1. Products listed for 25/50 resistive construction.

1.8 REGULATORY REQUIREMENTS

A. Perform Work in accordance with State of Illinois Plumbing Code, 2014 edition.

1.9 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum five (5) years of documented experience.
B. Installer: Company specializing in performing Work of this section with a minimum fove (5) yets documented experience.

1.10 PRE-INSTALLATION MEETING

A. Division 1 Specification Sections – Administrative Requirements, Pre-installation meetings.
B. Convene minimum one week prior to commencing Work on this section or as required by Construction Manager.

1.11 DELIVERY, STORAGE, AND PROTECTION

A. Delivery products to site under provisions of Division 1 General Requirements.
B. Store and protect products under provisions of Division 1 General Requirements.
C. Accept valves on site in shipping containers with labeling in place. Inspect for damage.
D. Provide temporary protective coating on cast iron and steel valves.
E. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.

F. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

1.12 ENVIRONMENTAL REQUIRMENTS

A. Division 1 Specification Selections – Product Requirements.
B. Do not install underground piping when bedding is wet or frozen.

1.13 FIELD MEASUREMENTS

A. Verify field measurements prior to fabrication.

1.14 WARRANTY

A. Division 1 Specification Sections – Execution Requirements: Product warranties and product bonds.
B. Provide three (3) year manufacturer warranty for domestic water piping.

PART 2 - PRODUCTS

2.1 SANITARY SEWER AND VENT PIPING, BURIED

A. Cast Iron Pipe: ASTM A74 service weight.
   1. Fittings: Cast iron.
   2. Joints: Hub-and-spigot, CISPI HSN compression type with ASTM C564 neoprene gaskets or lead and oakum.
B. Polyvinyl Chloride (PVC) Pipe: ASTM D2665, schedule 40.
   1. Fittings: Schedule 40, PVC to match pipe.
   2. Joints: Solvent weld with colored primer.

2.2 SANITARY SEWER PIPING, ABOVE GRADE

A. Cast Iron Pipe: ASTM A74, service weight.
   1. Fittings: Cast iron.
   2. Joints: ASTM C564, neoprene gasket system or lead and oakum.
B. Cast Iron Pipe: CISPI 301, hubless, service weight.
   1. Fittings: Cast iron.
   2. Joints: Neoprene gaskets and full, heavy-duty stainless-steel clamp assemblies.
C. Polyvinyl Chloride (PVC) Pipe: ASTM D2665, schedule 40 – Cannot be used in plenum ceilings
   1. Fittings: Schedule 40, PVC to match pipe.
   2. Joints: Solvent weld with colored primer.

2.3 SANITARY VENT PIPING, ABOVE GRADE

A. Cast Iron Pipe: ASTM A74, service weight.
   1. Fittings: Cast iron.
   2. Joints: ASTM C564, neoprene gasket system or lead and oakum.
B. Cast Iron Pipe: CISPI 301, hubless, service weight.
   1. Fittings: Cast iron.
   2. Joints: Neoprene gaskets and fully, heavy-duty stainless-steel clamp assemblies.
C. Polyvinyl Chloride (PVC) Pipe: ASTM D2665, schedule 40 – Cannot be used in plenum ceilings
   1. Fittings: Schedule 40, PVC to match pipe.
   2. Joints: Solvent weld with colored primer.

2.4 WATER PIPING, BELOW GRADE

A. Pipe Sizes Under 3 Inches: NOT ALLOWED.
B. Pipe Sizes 3 Inches & Larger: Ductile Iron Pipe: AWWA C151, Class 52 with AWWA C105 polyethylene encasement.
   1. Fittings: AWWA C110, Class 250 ductile iron, standard thickness.
   2. Joints: AWWA C111, Class 250 mechanical joints (MJ) with rubber gasket, retainer gland, bolts and ¾-inch diameter rods.

2.5 WATER PIPING, ABOVE GRADE

A. Copper Tubing: ASTM B88, Type L, hard drawn (all sizes).
   1. Fittings: ASME B16.18, cast copper alloy or ASME B16.22, wrought copper and bronze. Contractor may utilize mechanically formed tee and coupling connections.
   2. Joints: ASTM B32, solder, Grade 95TA or AWS5.8, B-Cup silver braze for mechanically formed connections.

2.6 STORM WATER PIPING, BELOW GRADE

A. Cast Iron Pipe: ASTM A74 service weight.
   1. Fittings: Cast iron.
   2. Joints: ASTM C564, neoprene gasket system.

2.7 STORM WATER PIPING, ABOVE GRADE

A. Cast Iron Pipe: ASTM A74 service weight.
   1. Fittings: Cast iron.
   2. Joints ASTM C564, neoprene gasket system.
B. Cast Iron CISPI 301, Hubless – service weight.
   1. Fittings: Cast Iron.
   2. Joints: Neoprene gaskets and stainless-steel clamp-and-shield assemblies.

2.8 FLANGES, UNIONS, AND COUPLINGS

A. Pipe Size 3 Inches and Under: 150 psig malleable iron unions for threaded ferrous piping; bronze unions for copper pipe, soldered joints.
B. Pipe Size Over 3 Inches: 150 psig forged steel slip-on flanges for ferrous piping; bronze flanges for copper piping; neoprene gaskets for gas service; 1/16-inch-thick performed neoprene.
C. Dielectric Connections: Union with galvanized or plated steel threaded end, copper solder end, water impervious isolation barrier.

2.9 PIPE HANGERS AND SUPPORTS

A. Refer to Section 15140: Pipe Hangers & Supports.

2.10 BALL VALVES (BV) – ALL VALVES SHALL BE LEAD FREE

A. Up to and Including 2 Inches:
   1. Manufacturers:
      a. Hammond Valve – Model UP8513 Lead Free.
      b. Milwaukee Valve – Model UPBA-150S Lead Free.
      c. Nibco Valve – Model S-585-66-LF Lead Free.
      d. Kitz Corporation – Model 869 Lead Free.
      e. Jomar – Model JP-100SSG Lead Free.
      f. Substitutions: Not Permitted.
B. MSS SP-110, 600 psi WOG, bronze, two-piece body, chrome plated ball, full port, Teflon seats and stuffing box ring, blow-out proof stem, lever handle, solder ends.

2.11 BALANCING FITTINGS (BF) – ALL BALANCE FITTING SHALL BE LEAD FREE

A. Up to and Including 2 Inches:
   1. Manufacturers:
      a. Armstrong Pump Co - Model CBV-Lead Free.
      b. Tour/Anderson Lead Free.
      c. Bell & Gossett/ITT – model CB – Lead Free.
      d. Flow Design, inc. Model Flowset – Lead Free.
B. Construction: 150 psi WOG (minimum), wye bodied bronze globe valve with bronze stem and seat calibrated and readable balance fittings with readout ports fitted with integral check valves to prevent loss of fluid when attaching monitoring kit.
C. Calibration: Integral indicating degree of valve opening with positive shut-off and memory stop.

2.12 SWING CHECK VALVES (CK) – ALL CHECK VALVES SHALL BE LEAD FREE

A. Up To and Including 2 Inches:
   1. Manufacturers:
      a. Hammond Valve.
      b. Milwaukee Valve.
      c. Nibco Valve.
      d. Stockham.
   2. MSS SP-80, Class 125, bronze body and cap, bronze swing disc with rubber seat, solder ends.
   3. Valve shall be lead free model.

2.13 FIRE AND SMOKE PENETRATION SEALANTS

A. Fire Seal:
   1. Seal penetrations of fire-rated walls, floors or ceilings by raceways for compliance with NEC 300-21.
      a. Acceptable Manufacturers:
         1) Hilti – FS-ONE MAX High Performance.
         2) Dow Corning: Fire Stop.
         3) 3M Co.: Fire Barrier.
         4) Rectorseal – Flamesafe.
         5) Oatey Co: Flame Barrier.
      b. Fill void around raceways.
      c. Sleeves: Heavy wall steel pipe, anchored to building construction and finished plumb with wall, ceiling to floor lines.
      d. Provide chrome plated steel escutcheon plate at all exposed pipe penetrations.

B. Thermal Seal:
   1. Seal penetrations of thermally insulated equipment or rooms to prevent heat transfer.
   2. Dual exterior of raceway with fiberglass or other material compatible to equipment or room and approved by Architect/Engineer.
   3. Seal interior of raceway with duct sealing compound at entry to equipment or room.
   4. Provide chrome plated steel escutcheon plate at all exposed pipe penetrations.

C. Water Seal:
   1. Seal penetrations of perimeter walls or floors below grade to prevent entry of water; use materials compatible with wall or floor construction and approved by Architect/Engineer.
   2. Seal Penetrations of Room: Sealed with flashings compatible with roof design and approved by roofing system manufacturer and Architect/Engineer.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that excavations are to required grade, dry, and not over-excavated.

3.2 PREPARATION

A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
B. Remove scale and dirt, on inside and outside, before assembly.
C. Prepare piping connections to equipment with flanges or unions.
D. Contactor to employ the services of a Ground Penetrating Radar Specialist to perform x-ray of areas requiring saw-cutting, prior to actual saw-cutting.

3.3 INSTALLATION

A. Install in accordance with State of Illinois Plumbing Code (2014).
B. Provide non-conducting dielectric connections wherever jointing dissimilar metals (i.e. copper to steel/iron pipe.).
C. Route piping in orderly manner and maintain gradient. Route parallel and perpendicular to walls.
D. Install piping to maintain headroom, conserve space, and not interfere with use of space.

E. Group piping whenever practical at common elevations.
F. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
G. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings. Refer to Section 15260.
H. Provide access where valves and fittings are not exposed.
I. Install vent piping penetrating roofed areas to maintain integrity of roof assembly. Locate vents at a minimum of 15 ft. away from air intake assemblies. Piping to extend min. 2'-6" above roof.
J. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.
K. Prepare exposed, unfinished pipe, fittings, supports, and accessories ready for finish painting.
L. Install bell and spigot pipe with bell end upstream.
M. Refer to Specification Section 15430 – Plumbing Specialties for product requirements, placement, and size requirements for cleanouts.
N. Install valves with stems upright or horizontal, not inverted.
O. Install water piping to ASME B31.9.
P. Sleeve pipes passing through partitions, walls, and floors. Provide chrome plated steel escutcheon plates at all exposed pipe penetrations.
Q. Slope water piping and arrange to drain at low points. Provide drain valves at low points.
R. Sizing:
    1. Unless otherwise indicated, install all supply piping, including shut-off valves, strainers and accessory fixtures to pumps, fixtures and other equipment at line size with reduction in size being made only at inlet to control valve, fixture or pump.
    2. Install supply piping from outlet of control valve at full size connection to equipment served.
S. Make reduction in water pipes with eccentric reducing fittings installed to provide drainage and venting.
T. Branch Take-Offs:
    1. Liquids: From top, bottom or side of mains or headers at either 45 degrees or 90 degrees from horizontal plane.
    2. Do not project branch pipes inside main pipe.
U. Pipe Drainage Provision:
    1. Slope water piping 1 inch in 40 feet and arrange to drain at low points.
V. Underground Pipe:
    1. Lay in dry trenches maintained free of accumulated water.
    2. Provide and operate sufficient pumping equipment to maintain excavations, trenches and pits free of water.
    3. Dispose of pumped water so operation areas and other facilities are not flooded.
    4. Pipe laying follows excavating close as possible.
W. Interior Sanitary Soil Waste, Vent:
    1. Connect underground sewers to site utilities at point 5 feet outside building walls or as specifically designated on drawings.
    2. Pitch sewers and branches as follows, unless otherwise indicated on drawings:
        a. Pipe, 3 Inches and smaller: Minimum 1/4 inch per foot.
        b. Pipe, 4 Inches and larger: Minimum 1/8 inch per foot, but no less than 1%.
    3. Continuously bed underground or on-ground piping on minimum 3 inch compacted sand or gravel, with depressions for hubs. Bed PVC pipe only on compacted sand bed; gravel not allowed.
    4. Compact backfilling for 6 inches, sides and tops; and 3 inches under pipe to 95% proctor.
    5. Complete backfilling to existing grade or to elevation indicated on Drawings, compacted to 95% proctor.
X. Mechanically formed Tee Connections:
    1. Mechanically extracted collars formed in continuous operation, consisting of drilling a pi-lot hole and drawing out tube surface to form a branch pipe collar having height of not less than a minimum of three (3) times the tube wall thickness.

a. Collaring Device: Fully adjustable to ensure proper tolerance and complete uniformity of joint.
2. Branch: Double notched to conform with inner curve of run tube and mechanically dim-pled to ensure penetration of branch tube into collar is of sufficient depth for brazing and that branch tube does not obstruct flow in main tube run.
3. All joints brazed in accordance with Copper Development Association Copper Tube Handbook using BCuP Series filler material.
a. Soft soldered joints will not be permitted.

Y. Mechanically formed Couplings:
1. Form couplings by first annealing area at end of tube where expansion will occur.
a. Insert tube expander to die size required and expand tube end to accept tubing of the same size.
b. Resulting joint is minimum three times as long as thickness of the tube.
2. All joints brazed in accordance with Copper Development Association Copper Tube Handbook using BCuP Series filler metal.

Z. Contractor to clean and flush all faucet aerators and strainers at final completion of project.

AA. Contractor to insulate all cold, hot, tempered, and all recirculation domestic water piping in accordance with Section 15260.

BB. Inserts:
1. Provide inserts for placement in concrete forms.
2. Provide inserts for suspending hangers from reinforced concrete slabs and sides of rein-forced concrete beams.
3. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
4. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
5. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut flush with top of slab.

CC. Pipe Hangers and Supports:
1. Install in accordance with ASTM B31.9 and MSS SP89. Refer to Section 230529: Sup-ports and Anchors for additional requirements.
2. Support horizontal piping as schedule
3. Install hangers to provide minimum ½ inch space between finished covering and adjacent work.
4. Place hangers within 12 inches of each horizontal elbow.
5. Use hangers with 1½-inch minimum vertical adjustment. Design hangers for pipe movement without disengagement of supported pipe.
6. Support vertical piping at every floor. Support riser piping independently of connected horizontal piping.
7. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
8. Prime coat exposed steel hangers and supports. Refer to Painting Section.
9. Hangers and supports located in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered expose.
10. Provide hangers adjacent to motor driven equipment with vibration isolation.

DD. Install pre-charged water hammer arrestors complete with accessible isolation ball valve. Install air hammer arrestor; size in accordance with PDI WH-210 Water Hammer Arrestor Standards. Water hammer arrestors must be accessible. Provide access panels as required.

3.4 APPLICATION

A. Install unions downstream of valves and at equipment or apparatus connections.
B. Install brass male adapters each side of valves in copper piped system. Solder adapters to pipe.
C. Provide balancing fittings flow controls in hot water recirculating systems where indicated.
D. Provide valve types as designated on drawings without deviation. All valves to be full line size of piping

3.5 DISINFECTION OF DOMESTIC WATER PIPING SYSTEM

A. Division 1 Specification Sections – Execution Requirements: Final Cleaning.
B. Prior to starting work, verify system is complete, flushed and clean.
C. Ensure Ph of water to be treated is between 7.4 and 7.6 by adding alkali (caustic soda or soda ash) or acid (hydrochloric).
D. Inject disinfectant, free chlorine in liquid, powder, tablet or gas form, throughout system to obtain 50 to 80 mg/L residual.
E. Bleed water from outlets to ensure distribution and test for disinfectant residual at minimum 15 percent of outlets.
F. Maintain disinfectant in system for 24 hours.
G. If final disinfectant residual tests less than 25 mg/L, repeat treatment.
H. Flush disinfectant from system until residual equal to that of incoming water or 1.0 mg/L.
I. Take samples no sooner than 24 hours after flushing, from 10 percent of outlets and from water entry, and analyze in accordance with AWWA C651.
J. Chlorinate and disinfect to point of new connection. Examine site water valving configuration to determine extent of chlorination. Contact site contractor to verify.
K. Submit reports in accordance with Division 1 General Requirements.

3.6 DOMESTIC HOT WATER RECIRCULATION SYSTEM BALANCING

A. Testing and balancing of domestic hot and domestic tempered water recirculation system provided under separate contract. Refer to Section 17800.

3.7 PIPE TESTING

A. Before final acceptance of piping, test all systems scheduled and prove to be free of leaks.
    1. Perform tests under observation of Construction Manager.
    2. Remove, replace or satisfactorily repair defective work revealed by tests
    3. Make piping repairs with new materials; caulking of screwed joints or pin holes not permitted.
    4. Underground systems tested before backfilling.
    5. Furnish test equipment and material for tests.
    6. Owner furnished water for testing and flushing.
B. Testing Medium:
    1. Hydrostatic Testing Medium: Clean pure water
C. Pressure Testing Gauges: ANSI B40.1, Grade AA; minimum 6-inch diameter dial with scale divisions equal or less than maximum allowable pressure drop.
D. Waste and Vent System Piping: Test with water and air before fixtures are set. TESTS SHALL TAKE PLACE PRIOR TO POURING CONCRETE FLOOR.
    1. Test with water and air before fixtures are set.
    2. Water Test:
        a. Apply to drainage and vent system in accordance or in entirety.
        b. When entire system is tested, tightly close all openings in pipes except highest single opening and fill system with water to overflow point.
        c. When system is tested in sections, tightly plug each opening except highest opening, fill each section with water and test each section with minimum 10 foot head of water; test each preceding section until entire system has been tested with minimum 10 foot of water, except uppermost 10 feet of system.
        d. Keep water in system, or in portion under test, for minimum 30 minutes before inspection.
        e. System must be tight at all joints; 1 inch in one hour leakage allowed.
    3. Air Test:
        a. Apply minimum 3 psi with force pump and maintain minimum 1 hour with no leakage apparent.
        b. Use mercury-column gauge in making test.

E. Domestic Water System:
   1. When rough-in is complete and before fixtures are set, test entire hot and cold water piping systems as scheduled and prove tight.
   2. Where portion of water piping system is concealed before completion, test that portion separately as specified for entire system.

F. Testing Requirements:
   1. Hydrostatic tests apply to piping indicated in Schedule in Paragraph G. below.
   2. Raise pressure gradually to given value; then block off source.
   3. Allowable Pressure Drop: Maximum amount scheduled during corresponding minimum time interval.
      a. Visually examine all joints during test.
   4. Upon successful completion and test approval, relieve piping of pressure, drain, put into normal operation except for potable water to be sterilized before placing in service.

G. Hydrostatic Testing Schedule:

Service	Normal Work Pressure psi	Hydrostatic Test Pressure psig	Maximum Pressure Drop psi	Minimum Time Hours
1. Domestic Water				
Portable Water	To 125	175	2	2

H. Submit test reports and certificates in accordance with Division 1 General Requirements.

END OF SECTION

SECTION 15430

PLUMBING SPECIALTIES

PART 1 - GENERAL

1.1 SECTION INCLUDES
A. Floor drains.
B. Cleanouts.
C. Roof Drains.
D. Backflow Preventers.
E. Thermostatic mixing valves.
F. Water hammer arrestors.

1.2 RELATED SECTIONS
A. Section 15190 – Mechanical Identification.
B. Section 15260 – Piping Insulation.
C. Section 15410 - Plumbing Piping.
D. Section 15440 – Plumbing Fixtures.
E. Section 15450 – Plumbing Equipment

1.3 REFERENCES
A. ANSI/ASSE 1011 - Hose Connection Vacuum Breakers.
B. ANSI/ASSE 1013 – Backflow Preventers, Reduced Pressure Principle.
C. ANSI/ASSE 1017 – Temperature Actuated Mixing Valves.
D. ANSI/ASSE 1070 – Devices that Limit Water Temperature to a Fixture.
E. ANSI A112.21.1 - Floor Drains.
F. ANSI A112.26.1 - Water Hammer Arresters.
G. ASME A112.6.3 – Floor and Trench Drains.
H. ASME A112.6.4 – Roof, Deck, and Balcony Drains.
I. PDI WH-201 Water Hammer Arresters.

1.4 REGULATORY REQUIREMENTS
A. Conform to State of Illinois Plumbing Code 2014.

1.5 SUBMITTALS
A. Submit under provisions of Division 1 General Requirements.
B. Shop Drawings: Indicate dimensions, weights and placement of openings and holes.
C. Product Data: Provide component sizes, rough-in requirements, service sizes and finishes.
D. Manufacturer's Installation Instructions: Indicate assembly and support requirements.
E. CONTRACTOR SHALL REVIEW ALL SHOP DRAWINGS PRIOR TO SUBMITTING THEM FOR ARCHITECT/ENGINEER'S REVIEW. CONTRACTOR SHALL STAMP EACH SHOP DRAWING TO CERTIFY THAT HE HAS REVIEWED IT. ENGINEER WILL NOT CHECK ANY SHOP DRAWINGS THAT CONTRACTOR HAS NOT STAMPED WITH HIS REVIEW CERTIFICATION. CONTRACTOR SHALL PROVIDE A LIST OF ITEMS SUBMITTED AT THE BEGINNING OF EACH SUBMTTAL. NO OLD OR OBSOLETE SUBMITTAL DOCUMENTATION SHALL BE ACCEPTED.

1.6 PROJECT RECORD DOCUMENTS
A. Submit under provisions of Division 1 General Requirements.
B. Record actual locations of equipment, cleanouts, backflow preventers and other devices.

1.7 OPERATION AND MAINTENANCE DATA
A. Submit under provisions of Division 1 General Requirements.
B. Maintenance Data: Include installation instructions, spare parts lists, exploded assembly views.

1.8 DELIVERY, STORAGE AND HANDLING
A. Deliver, store, protect and handle products to site under provisions of Division 1 General Requirements.
B. Accept specialties on site in original factory packaging. Inspect for damage.

1.9 EXTRA MATERIALS

A. Deliver to Maintenance Department prior to project completion. Submit written verification to Architect, Engineer, and Owner.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURER - PLUMBING SPECIALTIES

A. J.R. Smith.
B. Mifab Company.
C. Josam Co.
D. Tyler/Wade Co.
E. Watts Co.
F. Zurn Co.

2.2 ACCEPTABLE MANUFACTURERS – BACKFLOW PREVENTERS

A. Ames.
B. Watts.
C. No Substitutions.

2.3 ACCEPTABLE MANUFACTURERS – THERMOSTATIC MIXING VALVES

A. Watts Co.
B. No Substitutions.

2.4 FLOOR DRAINS

A. FD-1: ANSI A112.21.1; lacquered cast iron two-piece body with double drainage flange, 6-inch diameter heavy-duty nickel bronze secured square hole strainer, sediment bucket, vandal resistant fasteners and not flashed; Model 2010-A-6-NB manufactured by J.R. Smith, or equal.
B. FD-2: Lacquered cast iron body, 12-inch diameter adjustable ductile iron grate and sediment bucket, not flashed; Model 2360-M manufactured by J.R. Smith or equal.
C. FS-1: 12” x 12” x 8” deep cast iron body, acid resistant coated interior floor sink, nickel bronze half grate and sediment bucket with rubber feet; Model 3151-12 manufactured by J.R. Smith Co., or equal
D. Deep Seal P-Traps: Provide deep seal P-traps on all floor drains installed in the base slab.

2.5 CLEANOUTS

A. Interior Finished Floor Areas (FCO): Lacquered cast iron, two-piece body with double drainage flange, brass gasketed plug and adjustable nickel-bronze round vandal-proof serrated cover in unfinished areas and round with depressed cover to accept floor finish or with carpet markers in carpeted floor area; Model 4021-U manufactured by J.R. Smith, or equal.
B. Interior Finished Wall Areas (WCO): Line type with lacquered cast iron body and round brass gasketed plug and round stainless-steel access cover secured with vandal-proof fastener; Model 4532-U manufactured by J.R. Smith, or equal.
C. Interior Unfinished Accessible Areas (CO): Cast iron cleanout ferrule with brass tapered plug; Model 4425 manufactured by J.R. Smith, or equal.
D. Interior Unfinished Accessible Areas (CO): Cast iron cleanout ferrule with brass tapered plug; Model 4425 manufactured by J.R. Smith, or equal.

2.6 ROOF DRAINS

A. Roof Drains (RD-1 & RD-1-OF): ANSI A112.21.2: lacquered cast iron with sump, with side outlet elbow, removable cast iron dome, membrane flange and membrane clamp with integral gravel stop, with adjustable underdeck clamp, roof sump receiver and adjustable extension sleeve for roof insulation, speedi-set outlet or no-hub connection; See Fixture Schedule. No Substitutions.

B. Roof Drains (RD-2 & RD-2-OF): ANSI A112.21.2: lacquered cast iron with sump, removable cast iron dome, membrane flange and membrane clamp with integral gravel stop, with adjustable underdeck clamp, roof sump receiver and adjustable extension sleeve for roof insulation, speedi - set outlet or no - hub connection; See Fixture Schedule. No Substitutions.
C. Downspout Outlet (DSO): Cast bronze body and flange downspout nozzle with bird screen; Model 1770-BS manufactured by J.R. Smith.

2.7 BACKFLOW PREVENTERS

A. Reduced Pressure Backflow Preventers (BFP-1A & BFP-1B): ANSI/ASSE 1013; Lead free bronze body with bronze and stainless steel internal parts and stainless steel springs; two independently operating, spring loaded check valves; diaphragm type differential pressure relief valve located between check valves; third check valve which opens under back pressure in case of diaphragm failure; unit capable of operating up to 210 degrees F.; non-threaded vent outlet; assembled with two ball valves, strainer, four test cocks and vent outlet funnel drain; Model COLT 400 SERIES manufactured by Ames. No Substitutions. Provide strainer. Provide air gap per plumbing code. Ensure installation is compliant to Illinois Plumbing Code and AHJ. See Plumbing Fixture Schedule and Plumbing Drawings for sizes and locations. Note: BFP-1B is for Storm Shelter Area.
B. Double-check backflow preventer (BFP-2A & BFP-2B): ASNI/ASEE 1013; for fire protection service; lead free cast copper silicon alloy, silicon rubber dishes, union connectors, quarter turn valve, two in-line independent check valves, swivel feature, test cocks and funnel drain; Model Maxim Series M200 manufacturer by Ames. No Substitutions. Provide fire rated strainer. Provide air gap per plumbing code. Ensure installation is compliant to Illinois Plumbing Code and AHJ. See Plumbing Fixture Schedule and Plumbing Drawings for sizes and locations. Note: BFP-2B is for Storm Shelter Area.
C. Lead free Watts LF007M3QT (BFP-3): Double Check Valve Assembly for the protection of the potable water system. ANSI/ASSE 1015; lead free cast copper silicon alloy, top entry, replaceable disks and seats, tope mounted lead free test cocks. No Substitutions. Provide strainer. Provide air gap per plumbing code. Ensure installation is compliant to Illinois Plumbing Code and AHJ. Note: This backflow preventer is for protection of the water system at the mop basin.
D. Lead free Watts LF009M2QT (BFP-4): Reduced pressure principle backflow assembly for protection to the potable water system. ANSI/ASSE 1013; lead free cast copper silicon alloy, silicon rubber dishes, union connectors, quarter turn valve, two (2) in-line independent check valves, swivel feature, test cocks, and funnel drain. No Substitutions. Provide strainer. Provide air gap per plumbing code. Ensure installation is compliant to Illinois Plumbing Code and AHJ. Note: This backflow preventer is for protection of the potable water system at the Boiler Feed.

2.8 THERMOSTATIC MIXING VALVE (TMV)

A. Provide a thermostatic mixing valve assembly at each lavatory, sink or washfont. Thermostatic mixing valve shall be complete package with lead-free compression fittings on inlets, check valves, strainer with stainless-steel screen, and thermostat to control mix of hot and cold water.
B. Thermostatic mixing valve to be as Model LFUSG-B-M2 as manufactured by Watts; No Substitutions. See detail on drawing for piping configuration.

2.9 WATER HAMMER ARRESTORS

A. Provide PDI rated, pre-charged water hammer arrestors; size in accordance with PDI WH-210 Water Hammer Arrestor Standards. Water hammer arrestors must be accessible. Provide access panels as required.
B. Manufacturers:
   1. Watts – Model LF150A.
   2. Watts – Model LF15M2.
   3. Or Equal.

PART 3 - EXECUTION

3.1 PREPARATION

A. Coordinate cutting and forming of roof and floor construction to receive drains to required invert elevations.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.
B. Extend cleanouts to finished floor or wall surface. Lubricate threaded cleanout plugs with mixture of graphite and linseed oil. Ensure clearance cleanout for rodding of drainage system.
C. Coordinate floor cleanout cover types and styles with General Contractor's floor finish schedule.
D. Install each fixture, HVAC make-up water connection, and other devices with water hammer arrestor; size in accordance with PDI WH-201 Standards. Water hammer arrestors must be accessible. Provide access panels as required.
E. Install pre-charged water hammer arrestors complete with accessible isolation ball valve. Install air hammer arrestor; size in accordance with PDI WH-210 Water Hammer Arrestor Standards. Water hammer arrestors must be accessible. Provide access panels as required.
F. Pipe relief from backflow preventer to nearest drain. Ensure air gap is in compliance to Illinois Plumbing Code and AHJ.
G. Perform certification of all backflow preventers during substantial completion on accordance with Illinois Plumbing Code and AHU.
H. Provide side outlet roof drains on canopy roof area.
I. Provide deep seal P-traps for all slab-on grade floor drains.

END OF SECTION

SECTION 15440

PLUMBING FIXTURES

PART 1 - GENERAL

1.1 SECTION INCLUDED
A. Water closets.
B. Lavatories.
C. Sinks
D. Service sinks.
E. Electric Water Coolers.
F. Urinals.
G. Carriers.
H. Wall Hydrants.
I. Wall Box.
J. Stops and Supplies.
K. P-Traps.
L. Sink Trim (ADA Lav Guard).

1.2 RELATED WORK
A. Section 15140 - Anchors and Supports.
B. Section 15410 - Plumbing Piping.
C. Section 15430 - Plumbing Specialties.
D. Section 15450 – Plumbing Equipment.

1.3 REFERENCES
A. ANSI A112.6.1 - Supports for Off-the-Floor Plumbing Fixtures for Public Use.
B. ANSI A112.18.1 - Finished and Rough Brass Plumbing Fixture Fittings.
C. ANSI A112.19.2 - Vitreous China Plumbing Fixtures.
D. ANSI A112.19.3 - Stainless Steel Plumbing Fixtures.
E. ANSI A112.19.26 – Hydraulic Performance Requirements for Water Closets and Urinals.
F. ANSI Z124.3 and Z124.6 - Composite Resin Castings.
G. ANSI/ASSE 1011 - Hose Connection Vacuum Breakers.
H. ANSI/ASSE 1017 - Temperature Actuated Mixing Valves.
I. ANSI/ASSE 1019 - Wall Hydrants, Frost Proof Automatic Draining Anti-Backflow Types.
J. ASSE 1070 – Performance Requirements for Water Temperature Limiting Devices.
K. ASSE 1071 - Performance Requirements for Temperature Actuated Mixing Valves for Plumbed Emergency Equipment
L. ASME A112.18.1 – Plumbing Supply Fittings.
M. ANSI A112.26.1 - Water Hammer Arresters.
N. PDI WH-201 Water Hammer Arresters.
O. ARI 1010 - Drinking Fountains and Self-Contained Mechanically Refrigerated Drinking Water Coolers.

1.4 REGULATORY REQUIREMENTS
A. Conform to State of Illinois Plumbing Code (2014).

1.5 QUALITY ASSURANCE
A. Fixtures: By same manufacturer for each product specified throughout.
B. Trim: By same manufacturer for each product specified throughout.
C. Flush Valves: By same manufacturer for each product specified throughout.
D. All exposed fixture trim shall be chrome plated.

1.6 SUBMITTALS
A. Submit product data under provisions of Division 1 General Requirements.
B. Include fixtures, sizes, rough-in dimensions, utility sizes, trim and finishes.

C. Contractor shall review all shop drawings prior to submitting them for Architect/Engineer's review. Contractor shall stamp each shop drawing to certify that he has reviewed it. Engineer will not check any shop drawings that Contractor has not stamped with his review certification. Contractor shall provide a list of items submitted at the beginning of each submittal. No old or obsolete submittal documentation will be accepted.

1.7 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provision of Division 1 General Requirements.
B. Include fixture trim exploded view and replacement parts lists.

1.8 WARRANTY

A. Provide manufacturer's warranty under provisions of Division 1 General Requirements.

1.9 DELIVERY, STORAGE AND HANDLING

A. Deliver products to site under provisions of Division 1 General Requirements.
B. Store, protect and handle products under provisions of Division 1 General Requirements.
C. Accept specialties on site in original factory packaging. Inspect for damage.

1.10 EXTRA MATERIALS

A. Deliver to maintenance building prior to project completion. Submit written verification to Architect/Engineer.
B. Provide the following quantities of the materials listed; one set of the following items for each building, one complete set for the Office / Dock Building and one complete set for the Maintenance Building:
   1. Two (2) faucet repair kits for each faucet type.
   2. Three (3) water closet flush valve repair kits; Sloan Valve Co.
   3. Three (3) urinal flush valve repair kits; Sloan Valve Co.
   4. Ten (10) quarter turn fixture stops.
   5. Four (4) water cooler filter replacement cartridges.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS - LAVATORIES

A. American Standard Co.
B. No Substitutions.

2.2 ACCEPTABLE MANUFACTURERS - FIXTURE TRIM

A. Chicago Faucet (mop sink and kitchen sink)
B. Moen (lavs)
C. No Substitutions.

2.3 ACCEPTABLE MANUFACTURERS – WATER CLOSETS

A. American Standard Co.
B. No Substitutions.

2.4 ACCEPTABLE MANUFACTURERS - FLUSH VALVES

A. Sloan Valve Co.
B. No Substitutions.

2.5 ACCEPTABLE MANUFACTURERS – TOILET SEATS

A. Bemis.
B. Church.
C. Olsonite.
D. American Standard.

2.6 ACCEPTABLE MANUFACTURERS - FIXTURE CARRIERS

A. J.R. Smith Mfg. Co.
B. Tyler/Wade Co.
C. Zurn Co.

2.7 ACCEPTABLE MANUFACTURERS – URINALS (UR)

A. American Standard.
B. No Substitutions

2.8 ACCEPTABLE MANUFACTURERS – SERVICE SINKS / MOP BASIN (MB-1)

A. Mustee.
B. No Substitutions

2.9 ACCEPTABLE MANUFACTURERS – WALL HYDRANT (WH-1)

A. Woodford.
    1. See Plumbing Fixture Schedule.
B. No Substitutions.

2.10 ACCEPTABLE MANUFACTURERS – WALL HYDRANT (WH-2)

A. Woodford.
    1. See Plumbing Fixture Schedule.
B. No Substitutions.

2.11 ACCEPTABLE MANUFACTURERS – ELECTRIC WATER COOLERS

A. Elkay Mfg. Co.
B. No Substitutions.

2.12 ACCEPTABLE MANUFACTURER - STOPS AND SUPPLIES

A. Brasscraft -- G2 Series quarter turn stops.
B. No Substitutions.

2.13 ACCEPTABLE MANUFACTURERS – DRAIN BOX

A. Guy Gray.
B. No Substitutions.

2.14 ACCEPTABLE MANUFACTURERS – P-TRAP

A. Dearborn Brass – 17 Gauge chrome plates brass without cleanout.
B. No Substitutions.

2.15 ACCEPTABLE MANUFACTURER – SINK AND LAVATORY TRIM (ADA LAV GUARD)

A. Truebro Lav Guard 2.
B. No Substitutions.

2.16 WATER CLOSET (WC-1 and WC-2)

A. Bowl: ANSI A112.19.2; wall hung, handicap height, manual lever, siphon jet white vitreous china closet bowl, with elongated rim, 1½-inch spud, china bolt caps; Model AFWALL 2257.001 manufactured by American Standard. No Substitutions.
B. Flush Valve: ANSI A112.19.6; exposed chrome plated, diaphragm type water closet flush valve assembly. Valve body, tailpiece and control stop will be in conformance with ASTM alloy classification for semi-red brass. Flush valve assembly to be constructed with dual filtered diaphragm for flush valve accuracy, skirted high back pressure vacuum breaker with bottom hex coupling nut, hand wheel angle checkstop, sweat solder adapter kit, and cast wall flange with set screw; Model Regal 111-1.28XL manufactured by Sloan Valve Co. No Substitutions.
C. Seat: Anti-microbial solid white plastic, open front, extended, self-sustaining continuous stainless-steel hinge, brass bolts, without cover.

D. Wall Mounted Carrier: ANSI A112.6.1; adjustable cast iron frame, integral drain hub and vent, adjustable spud. Lugs for floor and wall attachment, threaded fixture studs with nuts and washers.

2.17 WATER CLOSET (WC-3)

A. Bowl: ANSI A112.19.2; floor-mounted, 10-inch height, manual lever, siphon jet white vitreous china closet bowl, with round rim, 1½-inch spud, china bolt caps; Model Baby Devoro 2282.001 manufactured by American Standard. No Substitutions.
B. Flush Valve: ANSI A112.19.6; exposed chrome plated, diaphragm type water closet flush valve assembly. Valve body, tailpiece and control stop will be in conformance with ASTM alloy classification for semi-red brass. Flush valve assembly to be constructed with dual filtered diaphragm for flush valve accuracy, skirted high back pressure vacuum breaker with bottom hex coupling nut, hand wheel angle checkstop, sweat solder adapter kit, and cast wall flange with set screw; Model Regal 111-1.28XL manufactured by Sloan Valve Co. No Substitutions.
C. Seat: Anti-microbial solid white plastic, open front, extended, self-sustaining continuous stainless-steel hinge, brass bolts, without cover. Model 5001G.055 manufactured by American Standard. No Substitutions.

2.18 LAVATORY (L-1)

A. Basin: ANSI A112.19.2; white vitreous china; handicapped wall-hung lavatory 21 X 18 inch minimum, with 4-inch-high back, drillings on 4-inch centers, overflow and soap depression; Model Lucerne 0355.012 American Standard, No Substitutions.
B. Trim: ANSI A112.18.1; chrome plated vandal resistant combination supply fitting with offset open grid strainer and tailpiece, 0.5 GPM water aerator, vandal proof push tilt self-closing metering handles, TMV Watts LFUSG-B-M2, chrome plated 17-gauge brass P-trap without cleanout (installed parallel with wall) and arm with escutcheon; manufactured by Moen. Provide under sink protective pipe covering for P-trap, tailpiece, angle valves, supply tubing, and TMV; Model 103 as manufactured by Truebro, Inc. Trim to be Moen Faucet Model M Dura 8210F05, No Substitutions.
C. Wall Mounted Carrier: ANSI A112.6.1; cast iron and steel frame, lugs for wall attachment, exposed bracket supports, bearing plate and studs.
D. Stops: Chrome plated brass quarter turn stop, ⅜-inch O.D. flexible riser and female compression inlet.

2.19 LAVATORY (L-2)

A. Trim: ANSI A112.18.1; chrome plated vandal resistant combination supply fitting with offset open grid strainer and tailpiece, 0.5 GPM water aerator, vandal proof push tilt self-closing metering handles, TMV Watts LFUSG-B-M2, chrome plated 17-gauge brass P-trap without cleanout (installed parallel with wall) and arm with escutcheon; manufactured by Moen. Provide under sink protective pipe covering for P-trap, tailpiece, angle valves, supply tubing, and TMV; Model 103 as manufactured by Truebro, Inc. Trim to be Moen Faucet Model M Dura 8210F05, No Substitutions.
B. Stops: Chrome plated brass quarter turn stop, ⅜-inch O.D. flexible riser and female compression inlet.

2.20 LAVATORY (L-3)

A. Basin: Basin: ANSI A112.19.2; white vitreous china; handicapped wall-hung lavatory 21 X 18 inch minimum, with 4-inch-high back, drillings on 4-inch centers, overflow and soap depression; Model Lucerne 0355.012 American Standard, No Substitutions. Mount at height as indicated on Architectural Plans.

B. Trim: ANSI A112.18.1; chrome plated vandal resistant combination supply fitting with offset open grid strainer and tailpiece, 0.5 GPM water aerator, vandal proof push tilt self-closing metering handles, TMV Watts LFUSG-B-M2, chrome plated 17-gauge brass P-trap without cleanout (installed parallel with wall) and arm with escutcheon; manufactured by Moen. Provide under sink protective pipe covering for P-trap, tailpiece, angle valves, supply tubing, and TMV; Model 103 as manufactured by Truebro, Inc. Trim to be Moen Faucet Model M Dura 8210F05, No Substitutions.
C. Wall Mounted Carrier: ANSI A112.6.1; cast iron and steel frame, lugs for wall attachment, exposed bracket supports, bearing plate and studs.
D. Stops: Chrome plated brass quarter turn stop, ⅜-inch O.D. flexible riser and female compression inlet.

2.21 SINK (SK-1)

A. Sink is integral to counter top and furnished with cabinetry by Architect. Provide faucet and trim only. Contractor responsible for all fittings and connection to new sink and trim, No Substitutions. For all Classroom Sinks install flat top sink basket strainer only. Use Dearborn Brass model 815 on Classroom Sinks. For all Non-Classroom Sinks use commercial grade locking cup sink basket strainer. Use Dearborn Brass model 816 on Non-Classroom Sinks. Do not use locking cup sink basket strainer on Classroom Sinks.
B. Trim: ANSI A112.18.1; chrome plated vandal resistant ADA compliant brass supply fitting with renewable and interchangeable quarter turn operating units, gooseneck spout, 0.5 GPM water aerator, wrist blade handles TMV Watts LFUSG-B-M2, chrome plated 17-gauge brass P-trap without cleanout and arm with escutcheon; Model 1100-E35XKABCP manufactured by Chicago Faucet Co. Provide under sink protective pipe covering for P-trap, tailpiece, angle valves, supply tubing, and TMV; Model 103 as manufactured by Truebro, Inc. No Substitutions.
C. Stops: Chrome plated brass quarter turn stop, ⅜-inch O.D. flexible riser and female compression inlet.

2.22 SINK (SK-2)

A. Double sink is integral to counter top and furnished with cabinetry by Architect. Provide faucet and trim only. Contractor responsible for all fittings and connection to new sink and trim, No Substitutions.
B. Trim: ANSI A112.18.1; chrome plated vandal resistant ADA compliant brass supply fitting with renewable and interchangeable quarter turn operating units, gooseneck spout, 0.5 gpm water aerator, wrist blade handles; Model 1100-E35XKABCP by Chicago Faucet Co., No Substitutions. Chrome plated 17-gauge brass P-trap without cleanout and arm with escutcheon. Provide Dearborn Brass model 816 commercial grade locking cup sink basket strainer.
C. Stops: Chrome plated brass quarter turn stop, 3/8-inch O.D. flexible riser and female compression inlet.

2.23 SERVICE SINK RECEPTOR / MOP BASIN (MB-1)

A. Bowl: ANSI A112.19.1; 24 x 24 x 10 inches deep, structural fiberglass sink, with 10-inch-high sides, stainless steel curb caps, chrome plated strainer, cast iron P-trap with adjustable floor flange; Model 63M manufactured by Mustee. No Substitutions.
B. Trim: ANSI A112.18.1; exposed wall type chrome plated supply with lever handle spout, wall brace, vacuum breaker, hose end spout, strainers, eccentric adjustable inlets, integral screwdriver stops with covering caps and adjustable threaded wall flanges; Model 835-CP manufactured by Chicago Faucet Co. Provide Chicago Faucet 293-XKRCF sill faucet for chemical wash connection. No Substitutions.
C. Hose Clamp, Hose and Mop Hanger: ½-inch plain end reinforced rubber hose with wall mounted hose clamp and stainless-steel wall plate with mop hooks; Model 832-AA and 889-CC manufactured by Fiat Products Corp.

2.24 ELECTRIC WATER COOLER (EWC-1)

A. Fountain: ARI 1010; two station high-low surface handicapped mounted electric water cooler and bottle filling station with stainless steel top, vinyl on steel body, elevated anti-squirt bubblers with stream guard, front push button activation, automatic stream regulator, mounting bracket, bottle filler to have no touch sensor activated fill with automatic shut off, refrigerated with integral air cooled condenser; capacity of 8.0 gal/min. of 50 degrees F. water with inlet at 80 degrees F. and room temperature of 90 degrees F., 1/5 HP compressor; Model VRCTL8WSK manufactured by Elkay Mfg. Co. No Substitutions.

B. Stops: Chrome plated brass quarter turn stop, 3/8-inch O.D. flexible riser and female compression inlet. Provide chrome plated 1-1/2" O.D. 17-gauge brass P-trap without cleanout and arm with escutcheon.

2.25 URINAL (UR-1)

A. ANSI A112.19.2; white vitreous china, wall hung handicapped washout urinal with shields, integral trap, removable stainless-steel strainer, ¾-inch top inlet spud, wall mounted steel supporting hanger and 2-inch brass female threaded outlet with gasket and hanger bolts; Model 6590.001EC manufactured by American Standard. No Substitutions.

B. Flush Valve: ANSI A112.19.6; exposed chrome plated, sensor activated, diaphragm type urinal flush valve assembly with true mechanical override button and hard wired in wall sensor and transformer and electrical box positioning and support kit. Stainless steel vandal resistant sensor panel and frame with courtesy flush override button. Valve body, tailpiece and control stop will be in conformance with ASTM alloy classification for semi-red brass. - Flush valve assembly to be constructed with dual filtered diaphragm for flush valve accuracy, skirted high back pressure vacuum breaker with bottom hex coupling nut, hand wheel angle checkstop, sweat solder adapter kit, and cast wall flange with set screw; Model Regal 186-0.125 manufactured by Sloan Valve Co. No Substitutions.

C. Wall Mounted Carrier: ANSI A112.18.1; steel frame with tubular legs, lugs for floor and wall attachment, threaded fixture studs for fixture hanger and bearing plate.

2.26 STOPS

A. Stops: ANSI A112.18.1; chrome plated brass quarter turn stop, 3/8-inch O.D. flexible riser and 3/8-inch female compression inlet; Model G2 Series manufactured by Brasscraft.

B. No Substitutions.

PART 3 - EXECUTION

3.1 INSPECTION

A. Review millwork shop drawings. Confirm location and size of fixtures and existing rough-in before installation.

3.2 INSTALLATION

A. Install each water closet with neoprene rubber closet gasket; felt or wax rings will not be accepted.

B. Install each fixture with trap, easily removable for servicing and cleaning.

C. Provide chrome plated rigid or flexible supplies to fixtures with quarter-turn stops reducers and escutcheons on each service to fixture.

D. Install components level and plumb.

E. Install and secure fixtures in place with wall carriers and bolts.

F. Seal fixtures to wall and floor surfaces with sealant; color to match fixture.

G. Mount fixtures to the heights as specified on Architectural Drawings.

3.3 ADJUSTING AND CLEANING

A. Adjust stops or valves for intended water flow rate to fixtures without splashing, noise or overflow.
B. At completion, clean plumbing fixtures and equipment.
C. Solidly attach water closets to floor with new lag screws. Lead flashing is not intended hold fixture in place. Adjust closet flange as required.
D. Contractor to remove each aerator or strainer screen and flush piping system at each fixture.

3.4 FIXTURE ROUGH-IN SCHEDULE

A. Rough-in fixture piping connections in accordance with following table of minimum sizes for particular fixtures.

	Hot Water	Cold Water	Waste	Vent
Water Closet	----	1-inch	4-inch	2-inch
Lavatory	½-inch	½-inch	1½-inch	1½-inch
Service Sink	3/4-inch	3/4-inch	3-inch	2-inch
Electric water Coolers	----	½-inch	1½-inch	1½-inch
Urinals	----	1-inch	1½-inch	1½-inch
Sinks	½-inch	½-inch	1½-inch	1½-inch
Wall Hydrant (WH-1)	----	1-inch	----	----
Wall Hydrant (WH-2)	3/4-inch	3/4-inch	----	----

END OF SECTION

SECTION 15450

PLUMBING EQUIPMENT

PART 1 – GENERAL

1.1 SECTION INCLUDED

A. Domestic gas hot water heaters.
B. Domestic Electric Commercial Heat Pump Water Heater.
C. Expansion tanks.
D. Circulator pumps.

1.2 RELATED SECTIONS

A. Section 15410 - Plumbing Piping.
B. Section 15430 – Plumbing Specialties.
C. Section 15140 - Anchors and Supports.
D. Section 15190 - Mechanical Identification.
E. Section 15260 - Piping Insulation.
F. Section 16170 – Grounding and Bonding.
G. Section 16180 – Equipment Wiring.
H. Division 16 Specifications - Equipment Wiring Systems: Electrical characteristics and wiring connections.

1.3 REFERENCES

A. IECC (International Energy Conservation Code) – 2018.
B. ASHRAE 90.1 - Energy Conservation in New Building Design.
C. ASME Section 8D - Pressure Vessels.
D. NFPA 54 - National Fuel Gas Code.
E. NFPA 70 – National Electric Code.
F. State of Illinois Plumbing Code.

1.4 SUBMITTALS

A. Submit under provisions of Division 01 Specification Sections.
B. Product Data:
    1. Provide dimension drawings of water heaters, pumps, storage tanks, etc. indicating components and connections to other equipment and piping.
    2. Indicate equipment's capacity, connection sizes and power requirements.
    3. Provide certified pump curves showing pump performance characteristics with pump and system operating point plotted. Include NPSH curve when applicable.
    4. Provide manufacturer piping diagrams for review and/or modification by the Engineer. Compensate other trades due to system deviations from equipment scheduled.
    5. Provide electrical characteristics, connection requirements and wiring diagrams.
C. Shop Drawings:
    1. Indicate location and dimensions of saddles, manways, lining methods, anchors, attachments, lifting points, tappings, and drains.
    2. CONTRACTOR SHALL REVIEW ALL SUBMITTALS PRIOR TO SUBMITTING THEM FOR THE ARCHITECT/ENGINEER'S REVIEW. CONTRACTOR SHALL STAMP EACH DRAWING AND EACH PIECE OF PRODUCT DATA TO CERTIFY THAT HE HAS REVIEWED IT. ARCHITECT/ENGINEER WILL NOT REVIEW ANY SUBMITTAL THAT CONTRACTOR HAS NOT STAMPED WITH HIS REVIEW CERTIFICATION. CONTRACTOR SHALL PROVIDE A LIST OF ITEMS SUBMITTED AT THE BEGINNING OF EACH SUBMTTAL. NO OLD OR OBSOLETE SUBMITTAL DOCUMENTATION WILL BE ACCEPTED.
D. Submit manufacturer's installation instructions in accordance with Division 01 Specification Sections.
E. Submit manufacturer's certificate that pressure vessels meet or exceed specified requirements in accordance with Division 01 Specification Sections.

1.5 PROJECT RECORD DOCUMENTS

A. Submit project record documents under provisions of Division 01 Specification Sections.
B. Project Record Documents: Record actual locations of components and equipment.
C. Submit under provisions of Division 01 Specification Sections - Operation and Maintenance Data: Include operation, maintenance, and inspection data, replacement part numbers and availability, and service depot location and telephone number.
D. Submit under provisions of Division 01 Specification Sections - Warranty: Submit manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.
E. Submit ASME certifications for all pressure vessels completed and registered in Owners name.

1.6 QUALITY ASSURANCE

A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum five years documented experience.
B. Provide pumps with manufacturer's name, model number, and rating/capacity identified.
C. Ensure products and installation of specified products are in conformance with recommendations and requirements of the following organizations:
    1. American Gas Association (AGA).
    2. National Sanitation Foundation (NSF).
    3. American Society of Mechanical Engineers (ASME).
    4. National Electrical Manufacturers' Association (NEMA).
    5. Underwriters Laboratories (UL).
D. Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, operate within 25 percent of midpoint of published maximum efficiency curve.
E. Submit certification of start-up of systems by manufacturer’s authorized agent in accordance with Division 01 Specification Sections.

1.7 REGULATORY REQUIREMENTS

A. Conform to AGA and NFPA 54 requirements for water heaters.
B. Conform to ASME Section 8D for tanks.
C. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

1.8 DELIVERY, STORAGE, AND PROTECTION

A. Transport, handle, store and protect products to site under provisions of Division 01 Specification Sections.
B. Provide temporary inlet and outlet caps. Maintain caps in place until installation.
C. Contractor shall store all materials shipped to the site in a protected area. If material is stored outside of the building, it must be stored off the ground a minimum of six inches set on 6 x 6 planks and/or wood pallets. All material must be completely covered with waterproof tarps or visqueen. All piping and duct openings will have the ends closed to keep out dirt and other debris. No equipment will be allowed to be stored on the site unless it is setting on wood planks and is completely protected with weatherproof covers.

1.9 WARRANTY

A. Submit under provisions of Division 01 Specification Sections.
B. Provide five-year manufacturer warranty against leakage for all ASME constructed domestic water tanks and expansion tanks.
C. Provide manufacturer’s standard warranty on all other equipment.

PART 2 – PRODUCTS

2.1 DOMESTIC GAS HOT WATER HEATERS

A. Acceptable Manufacturer:
   1. American Water Heater
   2. No Substitutions.

B. Automatic, low Nox high efficiency, natural gas-fired pre-mix powered burner, sealed power direct vent, vertical storage type, 150 psig maximum working pressure; with 444 stainless-steel tank; spiral flue passage, hand hole cleanout, power blower combustion chamber, thermally insulated with minimum 2 inches (50 mm) glass fiber, encased in corrosion-resistant steel jacket; baked-on enamel finish; floor shield and legs.

C. Brass water connections and dip tube, drain valve, high-density powered anodes and ASME rated temperature / pressure relief and vacuum relief valves, factory condensate neutralization basin kit.

D. Unit approved by AGA as automatic storage water heater and for operating at 180 degrees F.

E. Automatic water thermostat with temperature range adjustable from 120 to 180 degrees F., gas pressure regulator, burner, 100 percent safety shut-off pilot and thermocouple.

F. Vertical venting concentric vent kit, through roof.

G. See schedule on drawings for sizes and capacities.

2.2 DOMESTIC ELECTRIC COMMERCIAL HEAT PUMP WATER HEATER

A. Acceptable Manufacturer:
   1. AO Smith.
   2. No Substitutions.

B. The Water Heater shall be Commercial Heat Pump Model Number CAHP-120 as Manufactured by A.O. Smith Water Products Company or Equivalent. Heater shall be rated at 12 kW @ 240V or 9Kw @ 208V, single phase, 60 cycle AC as listed by Underwriters Lavatories. (NOTE: Contractor is to verify actual Electrical requirements for this build out and coordinate with Electrical before ordering, purchasing, and installing this electric commercial hear pump water heater.) All models meet National Sanitation Foundations NSF-5 requirements. Water Heater shall have LCD display with built-in diagnostic and troubleshooting information. Thank shall be 119 gallon capacity with 160 psi working pressure and equipped with a commercial grade anode. All internal surfaces of the heater exposed to water shall be glass-lined with and alkaline borosilicate composition that has been fused to steel by firing at a temperature range of 1400 Deg. F. Internal power circuit fusing shall be provided. The heat pump water heater shall be capable of operating in Efficiency, Hybrid, or Electric only modes. 3/4” NPT inlet and outlet water connections shall be provided. The water heater shall have a three year limited warranty; the compressor, refrigeration components and all other parts shall have a one year limited warranty. Fully illustrated instruction manual to be included. Meets or exceeds the efficiency and standby loss requirements of the U.S Department of Energy and current edition of ASHRAE 118.1.

C. Storage Tank Construction: UL Listed, steel vertical arrangement.
   1. Pressure Rating: 160 psig.

D. Capacity and Characteristics: Refer to Domestic Electric Commercial Heat Pump Water Heater Schedule.

E. Contractor is to provide all required valves, piping, connections, controls, etc., manufacturers required components, and code required components to ensure entire installation is compliant to all applicable codes and AHJ,
   1. Refer to Manufacturers installation manual and all applicable codes.

F. Coordinate installation with Electrical Contractor.

2.3 WATER HEATER ACCESSORIES

A. Drain Pans: Corrosion-resistant metal with raised edge. Comply with ANSI/CSA LC 3. Include dimensions not less than base of domestic-water heater, and include drain outlet not less than NPS ¾ with ASME B1.20.1 pipe threads or with ASME B1.20.7 garden-hose threads.
B. Piping-Type Heat Traps: Field-fabricated piping arrangement according to ASHRAE/OESNA 90.1 or ASHRAE 90.2.
C. Heat-Trap Fittings: ASHRAE 90.2.
D. Combination Temperature-and-Pressure Relief Valves: ASME rated and stamped. Include relieving capacity at least as great as heat input, and include pressure setting less than domestic-water heater working-pressure rating. Select relief valves with sensing element that extends into storage tank.
E. Pressure Relief Valves: ASME rated and stamped. Include pressure setting less than domestic-water heater working-pressure rating.
F. Vacuum Relief Valves: ANSI Z21.22/CSA 4.4.
G. Shock Absorbers: ASSE 1010 or PDI-WH 201, Size A water hammer arrester.

2.4 EXPANSION TANKS

A. Acceptable Manufacturers:
   1. Amtrol, Inc.
   2. Bell & Gossett/ITT.
B. Construction: Welded steel, tested and stamped in accordance with Section 8D of ASME Code; supplied with National Board Form U-1, rated for working pressure of 150 psig, with flexible EPDM diaphragm approved for potable water sealed into tank, and steel base.
C. Accessories: Air-charging fitting, tank drain; pre-charge to 65 psig.
D. Size: Refer to Schedule on drawings.

2.5 IN-LINE CIRCULATOR PUMPS

A. Acceptable Manufacturers:
   1. Bell & Gossett/ITT.
   2. No Substitutions
B. Casing: Stainless Steel, rated for 175 psig working pressure, with stainless steel rotor assembly.
C. Impeller: Stainless Steel.
D. Shaft: AISI 420 Stainless Steel.
E. Bearing: Carbon Sleeve.
F. Gasket / O-Ring: EDPM.
G. Drive: Electronically commutated permanent magnetic motor (ECM Technology).
H. Pump shall be Lead Free for potable water use.
I. Performance: Refer to Schedule on drawings.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install water heaters in accordance with manufacturer's instructions and to AGA and NFPA 54 requirements.
   1. Provide support on 4-inch-high concrete equipment pad, independent of building structural framing members.
   2. Provide manufacturer approved/authorized start-up and certification. Submit start-up report to Architect/Engineer in accordance with Division 01 Specification Sections.
B. Coordinate all equipment with plumbing piping and related fuel piping, gas venting and electrical work to achieve proper operating system.
C. Domestic Hot Water Expansion Tanks:
   1. Provide support on 4-inch-high concrete equipment pad, independent of building structural framing members.

2. Clean and flush after installation. Seal until pipe connections are made.
3. Provide manufacturer approved/authorized start-up and certification. Submit start-up report to Architect/Engineer in accordance with Division 01 Specification Sections.

D. In-Line Circulator Pumps:
1. Provide line sized isolating valve and strainer on suction and line sized soft seated check valve and globe valve on discharge.
2. Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, and operate within 25 percent of midpoint of published maximum efficiency curve.
3. Provide hydronic indicator gauges.
4. Provide manufacturer approved/authorized start-up and certification. Submit start-up report to Construction Manager in accordance with Division 01 Specification Sections.

3.2 OWNER TRAINING BY INSTALLING CONTRACTOR

A. At the completion of the project, the Installing Contractor shall provide training for all the plumbing equipment for the Owner's staff. Training shall consist of two parts. Part One is a classroom situation which describes the equipment's operation, maintenance, and repair requirements. Part Two will be on-site (hands-on) training which will show the location of all devices and the operation and maintenance of all controls, devices, motors, etc. This training will be in addition to other training specified in the contract. Prior to commencement of training, Contractor shall provide Architect/Engineer with a schedule of dates, times, and agenda for each training session. This Contractor shall provide a minimum of eight (8) hours of training for work installed under this section of the contract. Contractor shall furnish a minimum of six (6) equipment manuals, maintenance manuals and repair parts list for all equipment and systems reviewed.

B. Submit Certification of Completion in accordance with Division 01 Specification Sections.

END OF SECTION

SECTION 15505

FUEL PIPING

PART 1 – GENERAL

1.1 SECTION INCLUDES
A. Pipe and pipe fittings.
B. Valves.
C. Gas pressure reducing regulators.
D. Natural gas piping system.

1.2 RELATED SECTIONS
A. Section 15140 – Supports and Anchors.
B. Section 15195 – Testing of HVAC Piping.

1.3 REGULATORY REQUIREMENTS
A. Illinois State Plumbing Code 2014, ISPC.
B. Building Officials and Code Administrators International, Inc., 2015 International Mechanical Code.
C. National Fire Protection Association, NFPA-54: Installation Code for Natural Gas Burning Appliances and Equipment.
D. National Electric Code, NEC, Spread of Fire Products of Combustion.

1.4 PROJECT RECORD DOCUMENTS
A. Submit under provisions of Division 1 General Requirements.

1.5 DELIVERY, STORAGE AND HANDLING
A. Store and protect products under provisions of Division 1 General Requirements.
B. Deliver and store valves in shipping containers with labeling in place.
C. Contractor shall store all materials shipped to the site in a protected area. If material is stored outside of the building, it must be stored off the ground a minimum of six inches set on 6 x 6 planks and/or wood pallets. All material must be completely covered with waterproof tarps or visqueen. All piping will have the ends closed to keep out dirt and other debris. No equipment will be allowed to be stored on the site unless it is sitting on wood planks and is completely protected with weatherproof covers.

PART 2 – PRODUCTS

2.1 NATURAL GAS PIPING, BURIED OUTSIDE THE BUILDING (UNLESS PROVIDED BY NICOR GAS)
A. Steel Pipe: ASTM A53 or A120, Schedule 40 black. Fitting: ASTM A234, forged steel welding type, with ANSI/AWWA C105 polyethylene jacket or double layer, half-lapped 10 mil polyethylene tape. Joints: ANSI/AWS D1.1, welded.

2.2 NATURAL GAS PIPING, ABOVE GRADE
A. Steel Pipe: ASTM A53 or A120, Schedule 40 black. Fittings: ANSI/ASME B16.3, malleable iron or ASTM A2434, forged steel welding type. Joints: Screwed for pipe 1-1/2 inches and under (exposed and accessible); ANSI/AWS D1.1, welded, for pipe two inches and over and for 1-1/2 inches and under (concealed and inaccessible; above ceiling).

2.3 FLANGES, UNIONS AND COUPLINGS
A. Pipe Size 1½-Inches and under: 150 psig malleable iron unions for threaded ferrous piping; bronze unions for copper pipe, soldered joints.
B. Pipe Size 2 Inches and over: 150 psig forged steel slip-on flanges for ferrous piping; bronze flanges for copper piping; neoprene gaskets for gas service; 1/16-inch-thick preformed neoprene.
C. Dielectric Connections: Union with galvanized or plated steel threaded end, copper solder end, water impervious isolation barrier.

2.4 ACCEPTABLE MANUFACTURERS - GAS COCKS

A. Stockham.
B. Eclipse, Inc.
C. Ladish Co.

2.5 GAS COCKS

A. Up to 2 Inches: Bronze body, bronze tapered plug, non-lubricated, Teflon packing, threaded ends.
B. Over 2 Inches: Cast iron body and plug, non-lubricated, Teflon packing, flanged ends.

2.6 BELOW GRADE PIPING PROTECTION

A. Factory applied, ANSI/AWWA C105 polyethylene jacket, bonded to pipe surface with hot-applied thermo-plastic adhesive.

2.7 CONCRETE EQUIPMENT PADS

A. Provide 6-inch concrete pad for mounting new gas meter and service. Verify overall pad dimensions with NICOR.

2.8 FIRE AND SMOKE PENETRATION SEALANTS

A. Fire Seal:
    1. Seal penetrations of fire-rated walls, floors or ceilings by raceways for compliance with NEC 300-21.
        a. Acceptable Manufacturers:
            1) Dow Corning: Fire Stop.
            2) Nelson: Flameseal.
            3) T & B: Flameseal.
            4) 3M Co.: Fire Barrier.
        b. Fill void around raceways.
        c. Sleeves: Heavy wall Schedule 40 steel pipe, anchored to building construction and finished plumb with wall, ceiling or floor lines.
B. Thermal Seal:
    1. Seal penetrations of thermally insulated equipment, walls or rooms to prevent heat transfer.
    2. Dual exterior of raceway with fiberglass or other material compatible to equipment or room and approved by Architect/Engineer.
    3. Seal interior of raceway with duct sealing compound at entry to equipment or room.
C. Water Seal:
    1. Seal penetrations of perimeter walls or floors below grade to prevent entry of water; use materials compatible with wall or floor construction and approved by Architect/Engineer.
    2. Seal Penetrations of Roof: Sealed with flashings compatible with roof design and approved by roofing system manufacturer and Architect/Engineer.

PART 3 – EXECUTION

3.1 SERVICE CONNECTIONS

A. Natural gas utility company shall modify existing or replace as required current gas service currently serving the building as indicated on contract documents. Utility shall provide a new gas meter and/or regulator(s) on inlet side of meter as required to meet the buildings new pressure and capacity requirements. Contractor to provide all gas regulators on the discharge side of the meter.
    1. School District will pay all utility connection and installation charges required for new service connection.
B. Contractor shall be responsible for installing from the leaving side of the meter, all gas piping, gas cocks, regulators, regulator vent piping, unions, hangers, supports and final connection to all new gas fired equipment.
C. Support all piping as called for in Section 15140, Supports and Anchors.

D. Run a vent line from each gas regulator, including the gas regulator at the gas meter, up through and/or above the roof and terminate with a goose neck a minimum of 18 inches above the roof. Provide insect screen on outlet of each vent pipe.
E. Install exterior gas piping on a minimum 4” sand bed approximately 30” below grade.
F. All gas piping in unfinished (exposed structure) areas to run exposed, tight to ceiling. All gas piping in finished (finished ceiling) areas to be run concealed, tight to structure above.
    1. All piping above inaccessible ceilings (i.e. drywall, plaster, etc.), buried in or under floor slabs or drops in walls or chases shall have welded or brazed joints, regardless of pipe size.
    2. All gas piping run on roof to be welded.
G. Install Schedule 40 steel pipe sleeves through all foundations, floors, walls and roofs. Each sleeve shall be sealed at both ends with one of the following:
    1. Fire Walls: Fire seal.
    2. Floors at Grade: Water seal.
    3. Floors Above Grade: Fire seal.
    4. Foundations and Outside Walls: Water seal.
    5. Walls (Not Fire walls): Thermal seal.
H. Gas piping mounted on roof shall be mounted on pipe stands. Mount on a maximum center line as called for on drawings.
I. All exposed exterior gas piping to be primed and painted with outdoor yellow paint.

END OF SECTION

SECTION 15510

HYDRONIC PIPING

PART 1 – GENERAL

1.1 WORK INCLUDED

A. Pipe and pipe fittings for:
   1. Heating/Cooling water system.
   2. Equipment drains and overflows.
B. Valves:
   1. Ball valves.
   2. Butterfly valves.
   3. Check valves.
   4. Gate or globe valves are not acceptable for isolation service on this project.

1.2 RELATED SECTIONS

A. Section 15140 - Supports and Anchors.
B. Section 15190 - Mechanical Identification.
C. Section 15195 - Testing of HVAC and Gas Piping.
D. Section 15260 - Piping Insulation.
E. Section 15515 - Hydronic Specialties.
F. Section 15540 – HVAC Pumps.
G. Section 15558 – Condensing Firetube Boilers.
H. Section 15620 – Indoor Condenserless Liquid Water Chiller with Remote Condenser.
I. Section 15790 – Air Coils.
J. Section 15836 - Terminal Heat Transfer Units.
K. Section 15838 – Vertical Unit Ventilators.
L. Section 15855– Air Handling Units.
M. Section 15930 –Air Terminal Units.
N. Division 17 - Building Automation System.

1.3 REFERENCES

A. ASME - Boiler and Pressure Vessel Codes.
B. ASME B16.3 - Malleable Iron Threaded Fittings Class 50 and 300.
C. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings.
D. ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
E. ASME B31.9 - Building Services Piping.
F. ASTM A53 - Pipe, Steel, Black and Hot Dipped, Zinc Coated Welded and Seamless.
G. ASTM B32 - Solder Metal.
H. ASTM B88 - Seamless Copper Water Tube.

1.4 SYSTEM DESCRIPTION

A. Where more than one piping system material is specified, ensure system components are compatible and joined to ensure the integrity of the system is not jeopardized. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.
B. Use unions, flanges, and couplings downstream of valves and at equipment or apparatus connections. Do not use direct welded or threaded connections to valves, equipment or other apparatus.
C. Use non-conducting dielectric connections whenever jointing dissimilar metals in systems.
D. Provide pipe hangers and supports in accordance with ASTM B31.9, MSS SP69 and ASTM F708.
E. Use flanged ball, lug end bubble tight positive shut-off butterfly valves for shut off and to isolate equipment, part of systems, or vertical risers.
F. Use ball or butterfly valves for throttling, bypass, or manual flow control services.
G. Use ¾-inch ball valves with cap for drains at main shut off valves, low points of piping, bases of vertical risers, and at equipment. Pipe to nearest floor drain.

1.5 INSTALLATION OF DIVISION 17 PRODUCTS

A. Install control valves, wells for temperature sensors and threaded sockets for pressure sensors in the locations directed by the BAS contractor.
B. Install BAS valves and sensors in the locations shown on the plans and as required to achieve the Division 17 Sequence of Operation.
C. Failure of this contractor to adequately coordinate his work with the BAS contractor shall not be justification for any request for additional payment.
D. This contractor shall include the cost of coordinating and installing related BAS components in his bid.

1.6 SUBMITTALS

A. Submit under provisions of Division 1 General Requirements.
B. Contractor shall review all shop drawings prior to submitting them for Architect/ Engineer's review. Contractor shall stamp each shop drawing to certify that he has reviewed it. Engineer will not check any shop drawings that contractor has not stamped with his review certification.

1.7 REGULATORY REQUIREMENTS

A. Conform to ANSI/ASME B31.9 code for installation of piping system.
B. Conform to 2015 International Mechanical Code.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site under provisions of Division 1 General Requirements.
B. Accept valves on site in shipping containers with labeling in place. Inspect for damage.
C. Provide temporary protective coating on cast iron and steel valves.
D. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
E. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

PART 2 – PRODUCTS

2.1 HOT/CHILLED WATER PIPING, ABOVE GROUND

A. Steel Pipe: ASTM A53 or A120, Schedule 40, black.
   1. Fittings: ANSI/ASTM B16.3, malleable iron or ASTM A234, forged steel welding type fittings.
   2. Joints: Welded for 2½” and larger.
B. Copper Tubing: ASTM B88, Type L, hard drawn.
   1. Fittings: ANSI/ASME B16.18, cast brass, or ASME B16.22, brazed wrought copper.
   2. Joints: ASTM B32 - Solder Grade 95TA.
C. All piping 2½-inches and above to be steel pipe as stated in paragraph A. above. All piping 2-inches and under to copper tubing as stated in paragraph B. above.

2.2 CONDENSATE DRAINS OVERFLOWS AND EQUIPMENT DRAIN PIPING

A. Copper Tubing: ASTM B88, Type L, hard drawn.
   1. Fittings: ANSI/ASME B16.18, cast brass, or ASME B16.22, brazed wrought copper.
   2. Joints: ASTM B32 - Solder Grade 95TA.

2.3 UNIONS, FLANGES, AND COUPLINGS

A. Unions for Pipe 2 Inches and Under:
   1. Copper Pipe: Bronze, soldered joints.
B. Flanges for Pipe Over 2 Inches:
   1. Ferrous Piping: 150 psig forged steel, slip on.
   2. Copper Piping: Bronze.
   3. Gaskets: 1/16-inch thick preformed neoprene.

2.4 BALL VALVES

A. Up to and Including 2-1/2 inches:
   1. Manufacturers:
      a. Milwaukee - Model BA1005.
      b. Nibco - Model T585-70.
      c. Stockham - Model S-216.
   2. Bronze one-piece body, stainless-steel ball, Teflon seats and stuffing box ring, lever handle with balancing stops, solder ends.

2.5 BUTTERFLY VALVES

A. Manufacturers:
   1. Milwaukee - Model C Series.
   2. Nibco - Model LD2000.
   3. Stockham - Model LD712.
B. Body: Ductile iron with resilient replaceable EPDM seat, wafer or lug ends, extended neck.
C. Disc: Aluminum bronze.
D. Operator: 10-position lever handle.

2.6 SWING CHECK VALVES

A. Up to and Including 2-Inches:
   1. Manufacturers:
      a. Milwaukee.
      b. Nibco.
      c. Stockham.
   2. Bronze body, bronze trim, bronze rotating swing disc, with composition disc, threaded ends.
B. Over 2-Inches:
   1. Manufacturers:
      a. Milwaukee.
      b. Nibco.
      c. Stockham.
   2. Iron body, bronze trim, swing disc, renewable disc and seat, flanged ends.

PART 3 – EXECUTION

3.1 PREPARATION

A. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.
B. Remove scale and dirt on inside and outside before assembly.
C. Prepare piping connections to equipment with flanges or unions.
D. Keep open ends of pipe free from scale and dirt. Protect open ends with temporary plugs or caps.
E. After completion, fill, clean, and treat systems.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.
B. Install heating water to ASME B31.9.
C. Route piping in orderly manner, parallel to building structure, and maintain gradient.
D. Install piping to conserve building space, and not interfere with use of space and other work.
E. Group piping whenever practical at common elevations.
F. Sleeve pipe passing through partitions, walls and floors. Pack fire seal between sleeve and pipe.
G. Slope piping and arrange to drain at low points.
H. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

I. Inserts: Refer to Section 15140.
J. Pipe Hangers and Supports: Refer to Section 15140.
K. Furnish and install ¾" ball valve, with hose connection and cap, at all high and low points in the piping system for vents and drains respectively.
L. Install and pipe, coupon racks, pot feeder and side stream filter per manufacturer's recommendations.
M. Pipe equipment and condensate drains to nearest floor/roof drain. Run pipe close to equipment bases to avoid tripping hazards.

END OF SECTION

SECTION 15515

HYDRONIC SPECIALTIES

PART 1 – GENERAL

1.1 WORK INCLUDED
A. Expansion tanks.
B. Air vents.
C. Air separators.
D. Strainers.
E. Pump suction fittings.
F. Combination pump discharge valves (triple duty type).
G. Relief valves.
H. Balancing fittings.
I. Water system hydronic indication units and piping.
J. This contractor shall install all control valves, furnished by BAS contractor, in piping system.
K. This contractor shall furnish all pipe wells in piping system

1.2 RELATED SECTIONS
A. Section 15510 - Hydronic Piping.
B. Section 15540 – HVAC Pumps.
C. Section 15545 - Chemical Water Treatment.
D. Division 17 – Building Automation System.

1.3 REFERENCES
A. ANSI/ASME - Boilers and Pressure Vessel Codes, SEC 8 D Rules for Construction of Pressure Vessels.

1.4 SUBMITTALS
A. Submit under provisions of Division 1 General Requirements.
B. Contractor shall review all shop drawings prior to submitting them for Architect/ Engineer's review. Contractor shall stamp each shop drawing to certify that he has reviewed it. Engineer will not check any shop drawings that contractor has not stamped with his review certification.

1.5 OPERATION AND MAINTENANCE DATA
A. Submit under provisions of Division 1 General Requirements.
B. Maintenance Data: Include installation instructions, assembly views, lubrication instructions, and replacement parts list.

1.6 DELIVERY, STORAGE, AND HANDLING
A. Deliver, store, protect and handle products to site under provisions of Division 1 General Requirements.
B. Accept valves on site in shipping containers with labeling in place. Inspect for damage.
C. Provide temporary protective coating on cast iron and steel valves.
D. Provide temporary end caps and closures on piping and fittings. Maintain in place until installation.
E. Protect piping systems from entry of foreign materials by temporary covers, completing sections of the work, and isolating parts of completed system.

PART 2 – PRODUCTS

2.1 DIAPHRAGM TYPE EXPANSION TANKS
A. Manufacturers:
   1. Bell & Gossett, ITT
   2. No Substitutions.
B. Construction: Welded steel, tested and stamped in accordance with ASME SEC 8 D; supplied with National Board Form U 1, rated for working pressure of 125 psig, with flexible diaphragm sealed into tank.

C. Accessories: Pressure gage and air charging fitting, tank drain; pre-charge to 12 psig. Provide service shut-off valves for yearly serving and draining of tank.

2.2 AIR VENTS

A. Manual Type: Short vertical sections of 2-inch diameter pipe to form air chamber, with 1/8-inch brass needle valve at top of chamber.
B. Float Type:
   1. Brass or semi steel body, copper, stainless steel valve and valve seat; suitable for system operating temperature and pressure; with isolating valve.
C. Washer Type.
   1. Brass with hydroscopic fiber discs, vent ports, adjustable cap for manual shut off, and integral spring-loaded ball check valve.

2.3 AIR SEPARATORS

A. Acceptable Manufacturers:
   1. Bell & Gossett, ITT.
   2. No Substitutions.
B. Combination Air Separators/Strainers:
   1. Steel, tested and stamped in accordance with ANSI/ASME SEC 8 D; for 125 psig operating pressure, with integral galvanized steel strainer, tangential inlet and outlet connections, and internal stainless-steel air collector tube.

2.4 STRAINERS

A. Size 2-inch and Under:
   1. Manufacturers:
      a. O.C. Keckley Co.
      b. Armstrong Machine Works.
      c. MetraFlex Co.
   2. Screwed brass or iron body for 175 psig working pressure, Y pattern with 1/32-inch stainless steel perforated screen.
B. Size 2½-inch thru 4-inch:
   1. Manufacturers:
      a. O.C. Keckley Co.
      b. Armstrong Machine Works.
      c. MetraFlex Co.
   2. Flanged iron body for 175 psig working pressure, Y pattern with 3/64-inch stainless steel perforated screen.
C. Size 5-inch and Larger:
   1. Manufacturers:
      a. O.C. Keckley Co.
      b. Armstrong Machine Works.
      c. MetraFlex Co.
   2. Flanged iron body for 175 psig working pressure, basket pattern with 1/8-inch stainless steel perforated screen.

2.5 PUMP SUCTION FITTINGS

A. Manufacturers:
   1. Bell & Gossett, ITT.
   2. No Substitutions.
B. Fitting: Angle pattern, cast iron body, threaded for 2-inch and smaller, flanged for 2½-inch and larger, rated for 175 psig working pressure, with inlet vanes, cylinder strainer with 3/16-inch diameter openings, disposable fine mesh strainer to fit over cylinder strainer, and permanent magnet located in flow stream and removable for cleaning.
C. Accessories: Adjustable foot support, blowdown tapping in bottom, gauge tapping in side.

2.6 COMBINATION PUMP DISCHARGE VALVES (TRIPLE DUTY VALVES)

A. Manufacturers:
   1. Bell & Gossett, ITT - Series D
   2. No Substitutions.

B. Valves: Straight or angle pattern, flanged cast iron valve body with bolt on bonnet for 175 psig operating pressure, non-slam check valve with spring loaded bronze disc and seat, stainless steel stem, and calibrated adjustment permitting flow regulation.

2.7 COIL HOOK-UP KITS

A. Manufacturers:
   1. Belimo
   2. Bell & Gossett, ITT.
   3. Nexus

B. Fabrication:
   1. Combination wye strainer and shut-off valve with one pressure/temperature port, drain valve, tailpiece and union end (equal to B & G model UBY).
      a. Design and Construction:
         1) The Valve shall have integral ball shutoff valve capable of 600 PSI service at 60°F, integral “Y” pattern strainer at 20 mesh, and union ended connection with configurable tail piece of female sweat, female NPT or male NPT.
         2) The valve shall have four plugged ¼” NPT Female threaded accessory ports.
         3) The valve shall have one ¼” NPT Female threaded accessory port with installed Pressure/Temperature measurement port utilizing double core elastomeric isolation for hypodermic insertion of temperature or pressure measuring instrument. The port shall have a cap.
         4) The valve shall have one ¼” female threaded NPT port in the end of the threaded strainer cap for the blow down of the strainer or the emptying of the coil. A drain valve shall be installed in the fitting and shall have a ball isolation valve and garden hose capped drain fitting.
         5) The valve shall have one ½” female threaded NPT port suitable for use in bypass piping considerations. The port shall be plugged.
         6) The valve shall have an EPDM O-ring installed in the mating area of the tail piece flange and the body.
   2. Union accessory with one pressure/temperature port, manual air vent, tailpiece and union end (equal to B & G model UA).
      a. Design and Construction:
         1) Manual Air Vent: bronze body and nonferrous internal parts; 150 psig working pressure, 225-degrees F operating temperature; manually operated with screwdriver or thumbscrew; and having 1/8-inch discharge connection and ½-inch inlet connection.
         2) The Union shall have union ended connection with configurable tail piece of female sweat, female NPT or male NPT
         3) The union shall have one ¼” NPT Female threaded accessory port with installed Pressure/Temperature measurement port utilizing double core elastomeric isolation for hypodermic insertion of temperature or pressure measuring instrument. The port shall have a cap.
         4) The union shall have one ¼” female threaded NPT port in the end of the threaded strainer cap for the air venting of the coil. An air venting valve shall be installed in the fitting.
         5) The valve shall have an EPDM O-ring installed in the mating area of the tail piece flange and the body.

3. Circuit setter calibrated balance, commissioning and shut-off valve with input side pressure/temperature port, output side pressure/temperature port, tailpiece and union end (equal to B & G model MC).
    a. Design and Construction:
        1) The Hydronic System Balancing flow control valve shall be constructed by the product manufacturer to provide the functions called for in this section. The valve shall not be field constructed to provide key functionality.
        2) For 1/2”-2”, the valve shall be bronze construction; incorporate integral ball shutoff valve; rated at 400 psi at 250ºF service for water; Have union nut & separate tail piece exit from body with O-ring seal between body and flange; Shall have round handle with memory stop and integral calibrated position indicator and nameplate.
        3) Shall have two NPT female threaded accessory port with installed pressure/temperature measurement port; Shall have one plugged ¼" female threaded NPT port.
        4) All flow control devices shall be supplied by a single source and certified flow tests, witnessed by a professional engineer, shall be available.
        5) Pump head requirement: The required differential pressure for the pump head shall be as required to allow for the flow of the controlled circuit to be maintained with the required differential pressure for manual proportional balance at a position not closed more than 30% of the rated travel of the valve.
4. Shut-off valve.
5. Control valve to be by the BAS contractor.

2.8 WATER SYSTEM HYDRONIC INDICATION UNITS

A. Acceptable Manufacturers:
    1. Flow Conditioning Corp.
    2. No Substitutions.
B. System shall consist of hydronic indicators and manifold valves to provide accurate pressure indications of pressure drop at all pumps and equipment.
C. Hydronic indicator shall meet ASA Grade A specifications for pressure gauges, accurate to 1%. Case shall be 4½-inch diameter, stem mounted, heavy steel with screwed ring and unbreakable crystal. Indicator shall have recalibrator, compound scale calibrated both in pounds and feet from full vacuum to selected pressure, twin tip pointer for accurate reading and quick-set dial for pressure comparison. Maximum indicator pressure shall at least equal pump shut-off head (when system pressure is at relief valve setting) and shall exceed this minimum by no more than 50 psi.
D. Manifold valve shall be spring return pushbutton manifold of rugged brass construction with ports for connection to system at indicated points and with test port connection for gauge calibration.
E. Hydronic indicator system shall be attached to system piping with heavy bracket at convenient height to permit easy pushbutton operation and dial observation.
F. Contractor shall provide and install needle isolation valves on all copper tubing location at connections to piping system.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install specialties in accordance with manufacturer's instructions to permit intended performance.
B. Where large air quantities can accumulate, provide enlarged air collection standpipes.
C. Provide manual air vents at system high points and as indicated.
D. For automatic air vents in ceiling spaces or other concealed locations, provide vent tubing to nearest drain.
E. Provide air separator on suction side of system circulation pump and connect to expansion tank.

F. Provide valved drain and hose connection on strainer blow down connection.
G. Provide pump suction fitting on suction side of base mounted centrifugal pumps. Remove temporary strainers after cleaning systems.
H. Provide combination pump discharge valve on discharge side of base mounted centrifugal pumps.
I. Support pump fittings with floor mounted pipe and flange supports.
J. Provide balancing fitting valves on water outlet from terminal heating units such as radiation, radiant panels, unit heaters, and fan coil units.
K. Provide relief valves on pressure tanks, low pressure side of reducing valves, heat exchangers, and expansion tanks.
L. Select system relief valve capacity so that it is greater than make up pressure reducing valve capacity. Select equipment relief valve capacity to exceed rating of connected equipment.
M. Pipe relief valve outlet to nearest floor drain tight to edge of concrete pad such that pipe does not cross any walkway or cause a tripping hazard.
N. Where one line vents several relief valves, make cross sectional area equal to sum of individual vent areas.
O. Provide coil hook-up kit for each terminal unit (i.e. fan coil, cabinet/suspended unit heater, finned tube, unit ventilator, etc.) and hot/chilled or hot water coil.

3.2 HYDRONIC INDICATORS

A. Install in accordance with manufacturer's instructions.
B. Install one water system hydronic indication unit at the following equipment:
    1. One (1) unit for each base mounted pump to read:
        a. Water in and out of pump.
        b. Discharge side of triple duty valve.
        c. Inlet side of end suction diffuser.
    2. One (1) unit on the hot water heating coil for each air handling unit to read:
        a. Inlet and outlet to heating coil.
        b. Inlet and outlet side of in-line circulation pump.
    3. One (1) unit on the chilled water cooling coil for each air handling unit to read:
        a. Inlet and outlet to cooling coil.
    4. One (1) unit at domestic hot water circulating pump, pump to read:
        a. Inlet and outlet of each pump.
    5. Domestic water system as shown on the Drawings.
    6. As indicated on drawings.

3.3 OPERATING AND MAINTENANCE DATA BY INSTALLING CONTRACTOR

A. Contractor shall furnish two (2) hard copies and two (2) electronic copies of equipment manuals, maintenance manuals and repair parts list for all equipment and systems reviewed. See General Requirements for additional requirements.

END OF SECTION

SECTION 15535

REFRIGERANT PIPING AND SPECIALTIES

PART 1 – GENERAL

1.1 WORK INCLUDED

A. Piping.
B. Refrigerant.
C. Moisture and liquid indicators.
D. Valves.
E. Strainers.
F. Check valves.
G. Pressure relief valves.
H. Filter driers.
I. Solenoid valves.
J. Expansion valves.
K. Receivers.
L. Flexible connections.

1.2 RELATED SECTIONS

A. Section 15260 – Piping Insulation.
B. Section 15620 – Indoor Condenserless Liquid Water Chiller with Remote Condenser.
C. Division 17 – Building Automation System.

1.3 REFERENCES

A. ANSI/ARI 495 - Refrigerant Liquid Receivers.
B. ANSI/ARI 710 - Liquid Line Dryers.
C. ANSI/ARI 750 - Thermostatic Refrigerant Expansion Valves.
D. ANSI/ASHRAE 15 - Safety Code for Mechanical Refrigeration.
E. ANSI/ASHRAE 34 - Number Designation of Refrigerants.
F. ANSI/ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.
G. ANSI/ASME B16.26 - Cast Copper Alloy Fittings for Flared Copper Tubes.
H. ANSI/ASME B31.5 - Refrigeration Piping.
I. ANSI/ASTM B88 - Seamless Copper Water Tube.
J. ANSI/ASME B32 - Solder Metal.
K. ASTM B280 - Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.
L. ANSI/AWS A5.8 - Brazing Filler Metal.
M. ANSI/AWS D1.1 - Structural Welding Code, Steel.
N. UL 429 - Electrically Operated Valves.

1.4 SYSTEM DESCRIPTION

A. Where more than one piping system’s material is specified, ensure system components are compatible and joined to ensure the integrity of the system is not jeopardized. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.
B. Provide pipe hangers and supports in accordance with ASTM B31.5 and Section 15140.
C. Liquid Indicators:
    1. Use line size liquid indicators in main liquid line leaving condenser.
    2. If receiver is provided, install in liquid line leaving receiver.
    3. Use line size on leaving side of liquid solenoid valves.
D. Valves
    1. Use service valves on suction and discharge of compressors.
    2. Use gage taps at compressor inlet and outlet.
    3. Use gage taps at hot gas bypass regulators, inlet and outlet.
    4. Use check valves on compressor discharge.
    5. Use check valves on condenser liquid lines on multiple condenser systems.
E. Refrigerant Charging Packed Angle Valve: Use in liquid line between receiver shut off valve and expansion valve.

F. Strainers:
   1. Use line size strainer upstream of each automatic valve.
   2. Where multiple expansion valves with integral strainers are used, use single main liquid line strainer.
   3. On steel piping systems, use strainer in suction line.
   4. Use shut off valve on each side of strainer.
G. Pressure Relief Valves: Use on ASME receivers and pipe to outdoors.
H. Permanent Filter Driers:
   1. Use in low temperature systems.
   2. Use in systems utilizing hermetic compressors.
   3. Use filter driers for each solenoid valve.
I. Replaceable Cartridge Filter Driers:
   1. Use vertically in liquid line adjacent to receivers.
   2. Use filter driers for each solenoid valve.
J. Solenoid Valves:
   1. Use in liquid line of systems operating with single pump out or pump down compressor control.
   2. Use in liquid line of single or multiple evaporator systems.
   3. Use in oil bleeder lines from flooded evaporators to stop flow of oil and refrigerant into the suction line when system shuts down.
K. Receivers:
   1. Use on systems 5 tons and larger, sized to accommodate pump down charge.
   2. Use on systems with long piping runs.
L. Flexible Connectors: Utilize at or near compressors where piping configuration does not absorb vibration.

1.5 SUBMITTALS

A. Submit under provisions of Division 1 General Requirements.
B. Shop Drawings: Indicate schematic layout of system, including equipment, critical dimensions, and sizes.
C. Contractor shall review all shop drawings prior to submitting them for Architect/ Engineer's review. Contractor shall stamp each shop drawing to certify that he has reviewed it. Engineer will not check any shop drawings that contractor has not stamped with his review certification.

1.6 OPERATION AND MAINTENANCE DATA

A. Submit under provisions of Division 1 General Requirements.
B. Maintenance Data: Include instructions for changing cartridges, assembly views, spare parts lists.

1.7 REGULATORY REQUIREMENTS

A. Conform to ANSI/ASME B31.5 for installation of piping system.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site under Division 1 General Requirements.
B. Deliver and store piping and specialties in shipping containers with labeling in place.
C. Protect piping and specialties from entry of contaminating material by leaving end caps and plugs in place until installation.
D. Dehydrate and charge components such as piping and receivers, seal prior to shipment, until connected into system.

PART 2 – PRODUCTS

2.1 PIPING

A. Copper Tubing: ASTM B280, Type ACR hard drawn or annealed.
   1. Fittings: ANSI/ASME B16.22 wrought copper.
   2. Joints: Braze, AWS A5.8 BCuP silver/phosphorus/copper alloy with melting range 1190 to 1480-degree F.

B. Copper Tubing to 7/8-inch OD: ANSI/ASTM B88, Type K, annealed.
   1. Fittings: ANSI/ASME B16.26 cast copper.
   2. Joints: Flared.

2.2 REFRIGERANT

A. Refrigerant: ASHRAE 34;
   1. 134a
   2. Puron/410

2.3 MOISTURE AND LIQUID INDICATORS

A. Indicators: Single port type, UL listed, with copper or brass body, flared or solder ends, sight glass, color coded paper moisture indicator with removable element cartridge and plastic cap; for maximum working pressure of 500 psig, and maximum temperature of 200 degrees F.

2.4 VALVES

A. UL listed, globe or angle pattern, forged brass body and bonnet, phosphor bronze and stainless-steel diaphragms, rising stem and handwheel, stainless steel spring, nylon seat disc, solder or flared ends, with positive backseating; for maximum working pressure of 500 psig and maximum temperature of 275 degrees F.

B. Packed Angle Valves:
   1. Forged brass or nickel-plated forged steel, forged brass seal caps with copper gasket, rising stem and seat with backseating, molded stem packing, solder or flared ends; for maximum working pressure of 500 psig and maximum temperature of 275 degrees F.

C. Service Valves:
   1. Forged brass body with copper stubs, brass caps, removable valve core, integral ball check valve, flared or solder ends, for maximum pressure of 500 psig.

2.5 FILTER DRIERS

A. Replaceable Cartridge Angle Type:
   1. Shell: ARI 710, UL listed, brass, removable cap, for maximum working pressure of 350 psig.

2.6 SOLENOID VALVES

A. Valve: ARI 760, pilot operated, copper or brass body and internal parts, synthetic seat, stainless steel stem and plunger assembly, with flared, solder, or threaded ends; for maximum working pressure of 500 psig. Stem shall permit manual operation in case of coil failure.

B. Coil Assembly: UL listed, replaceable with molded electromagnetic coil, moisture and fungus proof, with surge protector and color-coded lead wires, integral junction box.

PART 3 – EXECUTION

3.1 PREPARATION

A. Ream pipe and tube ends. Remove burrs.

B. Remove scale and dirt on inside and outside before assembly.

C. Prepare piping connections to equipment with flanges or unions.

3.2 INSTALLATION

A. Install refrigeration piping and specialties in accordance with manufacturer's instructions.
B. Route piping in orderly manner, with plumbing parallel to building structure, and maintain gradient.
C. Install piping to conserve building space and not interfere with use of space.
D. Group piping whenever practical at common elevations and locations. Slope piping one percent in direction of oil return.
E. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
F. Inserts: Refer to Section 15140.
G. Arrange piping to return oil to compressor. Provide traps and loops in piping, and provide double risers as required. Slope horizontal piping 0.40 percent in direction of flow.
H. Provide clearance for installation of insulation and access to valves and fittings.
I. Provide access to concealed valves and fittings.
J. Flood piping system with nitrogen when brazing.
K. Where pipe support members are welded to structural building frame, brush clean, and apply one coat of zinc rich primer to welding.
L. Prepare unfinished pipe, fittings, supports, and accessories ready for finish painting.
M. Insulate piping and equipment; refer to Section 15260.
N. Follow ASHRAE 15 procedures for charging and purging of systems and for disposal of refrigerant.
O. Provide replaceable cartridge filter driers, with isolation valves and valved bypass.
P. Locate expansion valve sensing bulb immediately downstream of evaporator on suction line.
Q. Provide external equalizer piping on expansion valves with refrigerant distributor connected to evaporator.
R. Install flexible connectors at right angles to axial movement of compressor, parallel to crankshaft.
S. Fully charge completed system with refrigerant after testing.
T. Provide electrical connection to solenoid valves.

3.3 FIELD QUALITY CONTROL

A. Test refrigeration system in accordance with ASME B31.5.
B. Pressure test system with dry nitrogen to 300 psig. Perform final tests at 27 inches vacuum and 300 psig using electronic leak detector. Test to no leakage.

3.4 REFRIGERATION PIPING DESIGN

A. All refrigeration piping shall be designed by the mechanical contractor based on ASHRAE recommended guidelines and the following:
    1. Size liquid piping for a maximum 6.0 PSI pressure drop and maximum velocity of 360 FPM.
    2. Size suction lines for maximum 2.0 PSI pressure drop at full load. At the lowest stage of unloading/compressor operation; design to minimum velocities of 500 FPM in horizontal lines and 1000 FPM in vertical lines: Install traps at the base of all suction risers and provide double suction risers if required.
    3. Size hot gas lines for maximum 6.0 PSI pressure drop at full load. At the lowest stage of unloading/compressor operation; design to minimum velocities of 500 FPM in horizontal lines and 1000 FPM in vertical lines: Install traps at the base of all hot gas risers and provide double risers if required.
B. Submit dimensioned shop drawings of all refrigeration piping to the engineer for review prior to fabrication.

3.5 REQUIRED COMPONENTS

A. Furnish and install a minimum of the following components for each refrigeration circuit:
   1. Filter Dryer
   2. Sight Glass / Moisture Indicator
   3. Pressure relief valve.
   4. Isolation valves at indoor and outdoor units.

B. Verify all requirements with equipment manufacturers.

END OF SECTION

SECTION 15540

HVAC PUMPS

PART 1 – GENERAL

1.1 WORK INCLUDED
A. Base mounted pumps.

1.2 RELATED SECTIONS
A. Section 15170 - Motors.
B. Section 15242 - Vibration Isolation.
C. Section 15260 - Piping Insulation.
D. Section 15510 - Hydronic Piping.
E. Section 15515 - Hydronic Specialties.
F. Division 17 – Building Automation System.

1.3 REFERENCES
A. ANSI/UL 778 - Motor Operated Water Pumps.
B. NFPA 70 - National Electrical Code.

1.4 PERFORMANCE REQUIREMENTS
A. Ensure pumps operate at specified system fluid temperatures without vapor binding and cavitation, are non-overloading in parallel or individual operation, and operate within 25 percent of midpoint of published maximum efficiency curve.

1.5 SUBMITTALS
A. Submit under provisions of Division 1 General Requirements.
B. Product Data: Provide certified pump curves showing performance characteristics with pump and system operating point plotted. Include NPSH curve when applicable. Include electrical characteristics and connection requirements.

1.6 OPERATION AND MAINTENANCE DATA
A. Submit under provisions of Division 1 General Requirements.
B. Operation and Maintenance Data: Include installation instructions, assembly views, lubrication instructions, and replacement parts list.

1.7 REGULATORY REQUIREMENTS
A. Products Requiring Electrical Connection: Listed and classified by UL.

1.8 WARRANTY
A. Contractor shall provide a one (1) year manufacturer’s warranty on parts on furnished equipment. Equipment parts warranty shall start at time of substantial completion. Contractor will provide a one (1) year warranty on all labor associated with the equipment and its’ installation. Warranty shall start at date of final payment. See General Requirements for additional requirements.

PART 2 – PRODUCTS

2.1 MANUFACTURERS
A. Bell & Gossett, ITT
B. No substitutions.

2.2 BASE MOUNTED PUMPS
A. Type: Horizontal shaft, single stage, direct connected, radially or horizontally split casing, for 175 psig maximum working pressure.
B. Casing: Cast iron, with suction and discharge gage ports, renewable bronze casing wearing rings, seal flush connection, drain plug, flanged suction and discharge.
C. Impeller: Bronze, fully enclosed, keyed to shaft.
D. Bearings: Grease lubricated roller or ball bearings.

E. Shaft: Alloy steel with copper, bronze, or stainless-steel shaft sleeve.
F. Seal: Carbon rotating against a stationary ceramic seat, viton fitted, 250 degrees F maximum continuous operating temperature.
G. Drive: Flexible coupling with coupling guard.
H. Baseplate: Cast iron or fabricated steel with integral drain rim.

2.3 MANUFACTURER'S FIELD SERVICES

A. Pump manufacturer shall furnish a factory trained service engineer without additional charge to start the units. Pump manufacturer shall maintain service capabilities to more than 100 miles from the jobsite.
B. The manufacturer shall furnish complete submittal wiring diagrams as applicable for field maintenance and service.

2.4 OPERATION AND MAINTENANCE DATA BY INSTALLING CONTRACTOR

A. At the completion of the project, the Installing Contractor shall provide furnish two (2) hard copies and two (2) electronic copies of equipment manuals, maintenance manuals and repair parts list for all equipment and systems reviewed. See General Requirements for additional requirements.

PART 3 – EXECUTION

3.1 PREPARATION

A. Verify that electric power is available and of the correct characteristics.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.
B. Provide access space around pumps for service. Provide no less than minimum as recommended by manufacturer.
C. Decrease from line size with long radius reducing elbows or reducers. Support piping adjacent to pump such that no weight is carried on pump casings. For close coupled or base mounted pumps, provide supports under elbows on pump suction and discharge line sizes 4 inches and over.
D. Provide line sized shut off ball valve and end suction diffuser on pump suction, and line sized combination pump discharge triple duty valve on pump discharge. See pump details on the drawings for all trim.
E. Provide air cock and drain connection on horizontal pump casings.
F. Provide drains for bases and seals, piped to and discharging into floor drains.
G. Check, align, and certify alignment of pumps prior to start up.
H. Lubricate pumps before start up.
I. Install base mounted pumps on concrete housekeeping base, with anchor bolts, set and level, and grout in place.

END OF SECTION

SECTION 15545

CHEMICAL WATER TREATMENT

PART 1 – GENERAL

1.1 SECTION INCLUDES
A. Cleaning of piping systems.
B. Chemical feeder equipment.
C. Chemical treatment.
D. Side stream filters.

1.2 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION
A. Section 15510 – Hydronic Piping.
B. Section 15515 – Hydronic Specialties.

1.3 REFERENCES
A. NFPA 70 - National Electrical Code.
B. International Building Code 2015.

1.4 SUBMITTALS
A. Submit under provisions of Division 1 General Requirements.
B. Product Data: Provide chemical treatment materials, chemicals, and equipment including electrical characteristics and connection requirements.
C. Manufacturer's Installation Instructions: Indicate placement of equipment in systems, piping configuration, and connection requirements.
D. Manufacturer's Field Reports: Indicate startup of treatment systems when completed and operating properly. Indicate analysis of system water after cleaning and after treatment.

1.5 PROJECT RECORD DOCUMENTS
A. Submit under provisions of Division 1 General Requirements.
B. Record actual locations of equipment and piping.

1.6 OPERATION AND MAINTENANCE DATA
A. Submit under provisions of Division 1 General Requirements.
B. Operation and Maintenance Data: Include data on chemical feed pumps, agitators, and other equipment including spare parts lists, procedures, and treatment programs. Include step by step instructions on test procedures including target concentrations.

1.7 QUALIFICATIONS
A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum ten years documented experience. Company shall have local representatives with water analysis laboratories and full-time service personnel.

1.8 REGULATORY REQUIREMENTS
A. Conform to applicable code for addition of non-potable chemicals to building mechanical systems, and to public sewage systems.
B. 2015 International Mechanical Code.

1.9 MAINTENANCE SERVICE
A. Furnish service and maintenance of treatment systems for one year from Date of Substantial Completion.
B. Provide bi-monthly technical service visits to perform field inspections and make water analysis on site. Detail findings in writing on proper practices, chemical treating requirements, and corrective actions needed. Submit two copies of field service report after each visit.
C. Provide laboratory and technical assistance services during this maintenance period.
D. Include two (2) hour training course for operating personnel, instructing them on installation, care, maintenance, testing, and operation of water treatment systems. Arrange course at start-up of systems.

E. Provide on-site inspections of equipment during scheduled or emergency shutdown to properly evaluate success of water treatment program and make recommendations in writing based upon these inspections.

1.10 MAINTENANCE MATERIALS

A. Provide sufficient chemicals for treatment and testing during warranty period.

1.11 EQUIPMENT

A. Water Treatment Contractor shall provide water treatment equipment systems for all water using systems as specified below. It shall be the responsibility of the Water Treatment Contractor to properly size all components of the equipment system. The Mechanical Contractor shall install these equipment systems per the Water Treatment Contractor's instructions.

1.12 WASTEWATER STANDARDS

A. Discharge from any chemically treated system shall be directed to sanitary sewers and shall not result in containment levels which are in excess of standards as set forth by the appropriate water pollution control authorities.

PART 2 – PRODUCTS

2.1 CHEMICAL TREATMENT MANUFACTURERS

A. Great Lakes Treatment.
B. Maram, Inc.
C. Nalco.
D. Elemental Solutions.

2.2 MATERIALS

A. System Cleaner:
   1. Liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products.
   2. Biocide.
B. Closed System Treatment (Water):
   1. Sequestering agent to reduce deposits and adjust pH.
   2. Corrosion inhibitors.
   3. Conductivity enhancers.

2.3 BY PASS (POT) FEEDER

A. By-Pass Feeder shall have five (5) gallon capacity, steel construction with maximum operating pressure of 200 psi at 200° F. By-pass feeder shall have 4" wide cast-iron top closure and 3/4" NPT inlet, outlet, and drain connections. The feeder cover shall be 1/4 turn, quick opening, with self-aligning floating seal. By-pass feeder shall be installed as shown on drawings.

2.4 SIDE STREAM FILTER

A. Filter Vessel - Filter vessel shall house replaceable cartridge type filters and be rated for industrial applications with maximum operating pressure of 150 psi at 250°F. Filter vessel shall be of 316 stainless-steel split-shell construction with V-band clamp and NPT inlet, outlet, bottom drain and top vent connections. Filter vessel shall be installed as shown on drawings and shall be sized to filter the equivalent of the system water capacity once every four (4) hours. Housing to be Quantrol QFP5X1-316 with 10" filters.

B. Filter Cartridges - Filter cartridges shall be wound polypropylene media with a tin core, 10-micron rating, and a maximum temperature rating of 200° F sized to properly fit the filter vessel. Filter cartridges shall be furnished in a quantity sufficient for six (6) complete changes of the filter vessel. Filter cartridges shall be changed when the pressure drop across the filter vessel exceeds 20 psi, or as recommended by Water Treatment Contractor.

2.5 MAKE-UP WATER METER

A. Water meter shall be cold water oscillating piston type rated for industrial use. Meter shall be of bronze construction with NPT union connections, standard register totalizing in gallons, maximum pressure rating of 150 psi, and maximum temperature rating of 110°F. Water meter shall be installed in the make-up water piping fitted with a three (3) valve by-pass.

2.6 CHEMICALS

A. Water Treatment Contractor shall provide chemical treatment products as specified for cleaning and for the control of scale formation, corrosion, and microbiological growth in all water using systems. The quantity of chemicals furnished shall be sufficient to develop desired treatment levels in all systems from time of start-up through the warranty period, or for a maximum of one year, whichever comes first. Water Treatment Contractor shall have the ability to recycle shipping containers, per DOT guidelines.

2.7 EQUIPMENT

A. Closed System Equipment:
   1. Provide and install for each piping system, one side stream filter and one bypass feeder, capacity five gallons, for the closed water systems. Filter shall be installed between the suction and discharge sides of the circulating pump(s).

PART 3 – EXECUTION

3.1 PREPARATION

A. Systems shall be operational, filled, started, and vented prior to cleaning. Use water meter to record capacity in each system.
B. Place terminal control valves in open position during cleaning.
C. Verify that electric power is available and of the correct characteristics.

3.2 CLEANING

A. General - Prior to acceptance by the Owner, all grease, dirt and metallic oxides shall be removed from each closed recirculating system. Equipment shall be provided to meter the water, filter system water, mix and inject the cleaning solution into the system. Mechanical Contractor shall inform Water Treatment Contractor of all system materials of construction, to insure chemical cleaner compatibility. A cleaning agent shall be circulated, wetting all metal surfaces and flushed from the system at completion. Supervision shall be as provided by Water Treatment Contractor.
B. Procedure - The Following Cleaning Procedure shall apply:
   1. The system shall be filled through a suitable water meter to determine total water capacity, taking care to bleed all air.
   2. Liquid Cleaner shall be added to the system at a dosage rate of twenty (20) gallons per one thousand (1000) gallons of system capacity. The Chemical Water Treatment Contractor shall verify cleaner strength.
   3. Hot Water Systems shall be heated to 160-180 degrees F and circulated for 24 hours.
   4. During the cleaning period, system water shall be circulated through the entire system. Mechanical Contractor shall insure that all small orifices (control valves, strainers, etc.) remain free of debris. A side stream filter shall be used for solids removal during the cleaning period. Filter media shall be changed as specified in the filter cartridge specifications.

5. When cleaning is complete, the system shall be drained and flushed with fresh water to remove the cleaning solution. Flushing shall continue until the total (M) alkalinity of the system water is within fifty (5) PPM of the total alkalinity of the make-up water.
6. Immediately following completion and verification of flushing, certification records covering the cleaning operation shall be submitted to the Mechanical Contractor. Records shall include: System volume, cleaner concentration, circulation time, volume of flush water and final alkalinity reading. Each system shall then be chemically treated as provided elsewhere in the specifications.

C. Chemicals - Grease, dirt, oil and metallic oxides shall be removed from each closed recirculating water system using a non-foaming, liquid cleaning agent formulated to lift a disperse organic soil and to chelate alkaline earth metals and metallic oxides.
D. Use neutralizer agents on recommendation of system cleaner supplier and approval of Architect/Engineer.
E. Remove, clean and replace strainer screens.
F. Inspect, remove sludge and flush low points with clean water after cleaning process is completed. Include disassembly of components as required.

3.3 INSTALLATION

A. Install in accordance with manufacturer's instructions.

3.4 CLOSED SYSTEM TREATMENT

A. Provide one filter and bypass feeder on each system. Install isolating and drain valves and necessary piping. Install around balancing valve downstream of circulating pumps unless indicated otherwise.
B. Introduce closed system treatment through filter when required or indicated by test.

3.5 PREPARATION FOR FINAL FILL

A. The piping system shall be hydrostatically tested to the required test conditions to assure no leaks.
B. Piping system shall be cleaned prior to system final fill of clean water. Dirt, weld slag, filings, oil, etc. shall be removed and flushed from the system prior to final fill.
C. All heat transfer equipment (chiller, boilers, etc.) shall be isolated while the field piping is being flushed.
D. For the initial flush Contractor shall meter and fill system with high quality water and Trisodium Phosphate (TSP). Water shall contain less than 100ppm $CaCO_3$ hardness and less than 50ppm chloride plus sulfate ions. Blended solution shall have a concentration of 5 pounds TSP per 50 gallons water. Circulate this blended solution for 8-12 hours.
E. Drain the system of TSP solution. Open the isolation valves to all heat transfer equipment. Using a meter refill, fill the system with high quality water.
F. Final flush shall be drained and metered. Contractor shall flush all excess water out of the system. Drain all low "pockets".

3.6 FILLING THE SYSTEM

A. Fill the systems with the specified solution concentration complete with all inhibitors, buffers, and anti-foam agent as specified. Provide a minimum level of 850 Nitrite (NO_2) within the building system.
B. Contractor shall vent system during fill. The air has to come out of the system to let the fluid in. Before the fill, check to make sure ALL control valves are in the OPEN position. During the fill, periodically check the valves. To ensure no loss of fluid, close them off as the system fills up.
C. After the system is filled and the air is properly purged, allow the fluid to circulate for 24 hours. Then, pull a sample using the sample kit provided by the manufacturer.
D. Contractor shall pull a second sample six-months after the initial fill, and on the anniversary of the fill. It is recommended these samples are to be sent to the manufacturer for analysis.

E. The analysis from the manufacturer should list the following for water system:
   1. pH, Color, Clarity
   2. Reserve Alkalinity, ml
   3. Inhibitors: Ferrous, Copper & Brass Corrosion Products
   4. Degradation Products
   5. Corrosives
   6. Scale Promoters
   7. Contaminants

F. Manufacturer report shall be submitted to the Engineer for the inclusion in the building submittal records for distribution to the Owner.

3.7 OPERATING AND MAINTENANCE DATA BY INSTALLING CONTRACTOR

A. Contractor shall furnish two (2) hard copies and two (2) electronic copies of equipment manuals, maintenance manuals and repair parts list for all equipment and systems reviewed. See General Requirements for additional requirements.

END OF SECTION

SECTION 15558

CONDENSING FIRETUBE BOILERS

PART 1 – GENERAL

1.1 WORK INCLUDES
A. Delivery of equipment to the job site.
B. Field start-up services and Owner training at the job site.
C. Parts and labor warranty.
D. High efficiency condensing hot water boilers.
E. Boiler trim and controls.
F. Gas burner and control panel.
G. Chimney connections.
H. Combined condensate neutralization basin. See drawings.
I. Factory mounted and wired controls and safeties.

1.2 REFERENCES
A. AGA - Directory of Certified Appliances and Accessories.
B. ANSI/AGA Z21.13 - Gas-Fired Low-Pressure Steam and Hot Water Boilers.
C. ANSI/AGA Z2223.1 - National Fuel Gas Code.
D. ANSI/ASME SEC4 - Boiler and Pressure Vessel Codes, Rules for Construction of Heating Vessels.
E. ANSI/NFPA 70 - National Electrical Code.
F. HI (Hydronics Institute) - Testing and Rating Standard for Cast Iron and Steel Heating Boilers.
G. NEMA 250 - Enclosure for Electrical Equipment (1000 Volts Maximum).

1.3 SUBMITTALS
A. Submit two (2) copies of unit performance data including capacity, nominal and operating performance.
B. Submit Mechanical Specifications for unit and accessories describing construction, components and options.
C. Submit shop drawings indicating overall dimensions as well as installation, operation and service clearances. Indicate lift points and recommendations and center of gravity. Indicate unit shipping, installation and operating weights including dimensions.
D. Submit data on electrical requirements and connection points. Include recommended wire and fuse sizes or MCA, sequence of operation, safety and start-up instructions.

1.4 OPERATION AND MAINTENANCE
A. Submit two (2) hard copies and one (1) PDF of manufacturer installation instructions and operation and maintenance data to successful contractor for inclusion in project manual.
B. Include manufacturer's descriptive literature, operating instructions, cleaning procedures, replacement parts list and maintenance and repair data to successful contractor for inclusion in project manual.

1.5 QUALITY ASSURANCE
A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum ten years documented experience.
B. Standards and Codes:
    1. The boiler/burner units shall meet or exceed the following code requirements:
        a. UL-795 (Underwriter’s Laboratories) Certification
        b. National Fire Protection Association/NFPA 70
        c. FM Global (Formally Factory Mutual)
        d. CSD-1
        e. AHRI, BTS-2000

1.6 REGULATORY REQUIREMENTS

A. Conform to ARI 550/590-98 Standard for testing and certified rating of Water Chilling Packages using the Vapor Compression Cycle.
B. Conform to ANSI/UL 1995 code for construction of water chillers. In the event the unit is not UL approved, the manufacturer shall, at his expense, provide for a field inspection by an UL representative to verify conformance to UL standards. If necessary, contractor shall perform modifications to the unit to comply with UL, as directed by the UL representative.
C. Conform to ANSI/ASME SEC 8 Boiler and Pressure Vessel Code for construction and testing of water chillers.

1.7 HANDLING

A. Comply with manufacturer's installation instruction for rigging, unloading and transporting units.
B. Protect units from physical damage. Leave factory shipping covers in place until installation.

1.8 WARRANTY

A. Provide two (2) year manufacturer's non-prorated warranty on all parts and two (2) year on labor from Date of Start-up. See General Requirements for additional requirements and start date.
B. Warranty shall include all control components factory mounted on the unit.
C. Provide twenty-five (25) year non-prorated warranty against thermal shock damage.

PART 2 – PRODUCTS

2.1 HIGH EFFICIENCY BOILERS

A. Manufacturers:
   1. Fulton Heating Solutions.
   2. No substitutions.

2.2 GENERAL

A. Furnish boilers as indicated on the drawings. Units shall be supplied in strict accordance with the specification. Packaged boilers shall be furnished complete including the following:
   1. Water Trim complying with UL, CSD-1, Factory Mutual (FM)
   2. Burner and Controls complying with UL. CSD-1, Factory Mutual (FM)
   3. Start-up Service

2.3 CONDENSING BOILER CONSTRUCTION

A. The boiler shall be completely factory assembled as a self-contained unit. Each boiler shall be neatly finished, thoroughly tested, and properly packaged for shipping.
B. The pressure vessel design and construction shall be in accordance with Section IV of the ASME Code for heating boilers. The boiler shall comply with CSD-1 code requirements.
C. The pressure vessel shell shall be a minimum 1/4” thick steel, SA-790 or SA-516 Grade 70 plate.
D. Tube sheets should be designed with low weld intensity with a tube to tube minimum spacing of 2” center to center and minimum 5/8” tube to tube ligament.
E. The firetube area of the heat exchanger where the flue gases will condense shall be constructed using duplex alloys of stainless steel. Alloys of the 300 series stainless steels, such as 316L or 304, have a relatively high coefficient of linear expansion and thus are unacceptable.
F. Heat exchange capability shall be maximized within the pressure vessel via the use of corrulator fire tube technology. All heat transfer enhancements shall be stainless steel; aluminum heat transfer enhancers are unacceptable.
G. Boilers with heat exchangers using cast aluminum, cast iron or copper finned tube design platforms are unacceptable.

H. The boiler shall be a fire tube design. The furnace location shall be such that all furnace components are within water-backed areas.
I. The water volume of the boiler shall not be less than 102 Gallons. Boilers having a lower water volume shall be supplied and piped with a buffer tank to make equivalent total volume of at least 102 gallons.
J. The pressure drop of the boiler shall not be greater than 5 PSIG with water flow of 250 gpm.

2.4 BOILER DESIGN

A. The boiler shall have its efficiency witnessed and certified by an independent third party, and the efficiency must be listed on the AHRI directory (www.ahridirectory.org) for natural gas operation. The test parameters for efficiency certification shall be the BTS-2000 standard. The certified thermal efficiency for natural gas firing shall not be less than 95.3%:
B. The boiler shall have no minimum return water temperature requirements.
C. A zero flow or low flow condition shall not cause any harm to the pressure vessel or heat exchanger of the boiler. Flow switches, dedicated circulator pumps, or primary/secondary piping arrangements are not required to protect the heat exchanger or pressure vessel from thermal shock or other system related considerations.
D. It shall be acceptable to vent the boiler using sealed combustion (drawing in fresh air from the outdoors) or to draw air from the mechanical room itself.
E. The boiler shall have a pre-mix combustion system, capable of operating at 4” wc incoming gas pressure while simultaneously achieving emissions performance, full modulation/turndown, and full rated input capacity.
F. The noise emission from the boiler shall not exceed 60dBA measured 5 feet from the front of the boiler at high fire and 55 dBa at low fire.

2.5 CONTROLS

A. Ignition shall be via direct spark. A UV scanner shall be utilized to ensure precise communication of flame status back to the flame programmer.
B. The boiler control system shall be supplied as part of a factory assembled and tested boiler control cabinet.
C. Boiler shall be provided with microprocessor-based flame safeguard control that incorporates a color touch screen display. The control system shall be fully integrated into the boiler control cabinet and incorporate single and multiple boiler control logic, inputs, outputs and communication interfaces. Controller shall provide boiler status, history and diagnostics information. Boiler control shall include the following features:
    1. Temperature (PID) load control capability
    2. Modbus controller
    3. Firing rate limiting
    4. Time of day display
    5. Enable/disable control of up to three (3) devices (pumps, valves, etc.) with programmable time delay for disable of the device(s)
    6. Customizable boiler name display
    7. Display fifteen (15) most recent alarms including equipment status at time of lockout
    8. Ability to accept a remote 0-10 volt for setpoint or firing rate (one or the other, not both)
    9. Password protect options
    10. Outdoor reset capabilities for an individual boiler with warm weather shutdown.
    11. Programmable limits for (information displayed on the boiler display) shall include:
        a. Outlet water temperature
        b. Exhaust/stack temperature
        c. Inlet water temperature
        d. Outdoor/ambient air temperature
    12. Integrated sequencing (lead/lag) functions for up to eight (8) boilers installed in the same hydronic loop.
    13. Outdoor air temperature reset

14. Boiler safety controls shall include:
    a. Operating Temperature Controller for automatic start and stop.
    b. High Limit Temperature Controller with manual reset.
    c. Low Water Cutoff Probe in the boiler shell.
    d. Air Safety Switch.
    e. Flame detector to prove combustion.
15. All controls shall be mounted and wired according to UL requirements. Electrical power supplied shall be 120/60/1.
16. Each individual boiler can enable/disable up to three (3) devices. The enable of each device, for example a pump or motorized isolation valve, will be simultaneous with the heat demand for that boiler. The disable of each device will be based on a programmable time delay when the heat demand is no longer present.
17. Provide provisions for the following hard-wired points:
    a. Boiler Enable/Disable.
    b. Boiler Status.
    c. Boiler Alarm.
    d. Boiler Reset (0-10 volt).
18. Provide each boiler with a factory installed Modbus controller.

2.6 BOILER FITTINGS & TRIM

A. The boiler shall be supplied with one 60# PSI ASME Section IV safety relief valve.
B. The boiler shall be supplied with a temperature/pressure gauge to be mounted on the water outlet piping of the boiler.
C. A condensate drain connection shall be available on the boiler, allowing flue gas condensate to freely drain out of the exhaust manifold of the boiler. A condensate drain trap assembly shall accompany the boiler system, along with pH neutralization basin.
D. Water supply and return connections on the boiler shall be minimum 4” and 150# flanged.
E. Boiler shall come with lifting eyes and fork truck accessibility for rigging.
F. Instructions for installation, operation and maintenance of the boiler shall be contained in a manual provided with each boiler.
G. A wiring diagram corresponding to the boiler configuration shall be included with each boiler.
H. Each boiler shall be installed and operated in a functioning hydronic system, inclusive of venting, as part of the manufacturing process. A factory test fire report corresponding to the boiler configuration shall be included with each boiler.

2.7 VENTING

A. Vent Material – The flue (exhaust) stack must be AL294C or equivalent material UL-1738/C-UL S636 approved for Category IV (condensing, positive pressure) applications. Vent connections must be located at the rear of the boiler.

2.8 REQUIREMENTS BY INSTALLING CONTRACTOR

A. Contractor shall furnish two (2) hard copies and two (2) electronic copies of equipment manuals, maintenance manuals and repair parts list for all equipment and systems reviewed. See General Requirements for additional requirements.
B. The boiler-burner manufacturer's representative, upon completion and start-up of the system shall submit to the Owner a written certified report that the installation of the complete system is in accordance with the specifications and the system is in proper operating condition. The report shall include at least the following:
    1. Stack temperature - high, medium and low fire.
    2. CO2 reading of the flue gas - high, medium, and low fire with combustion efficiency.
    3. Draft reading
    4. Voltage output of flame scanner

5. Operationally check for safety low water cutoff and all operating and limit controls as specified on boiler.
6. Operationally simulate pilot and main flame failure to check electronic flame safeguard control.
7. Record set-point readings of all limits and controls.

C. The certified report shall include, but shall not be limited to the operational checking of the following:
1. All remote-controlled boiler pumps for both automatic and manual operation.
2. Any other controls not herein specified that directly affect the operation and performance of equipment supplied under this section including the multiple boiler control panel.

PART 3 – EXECUTION

3.1 BOILERS

A. Cleaning
1. Before the boiler is put into operation, provide instruction to installing contractor for thoroughly boiling and drying out the boiler so as to remove all traces of oil, mill scale and dirt. Boiling and drying out shall be done in accordance with boiler manufacturer's recommendations.

B. Hydrostatic Test
1. A manufacturer's A.S.M.E. Data Sheet shall be furnished for each boiler showing shop inspection and tests. Contractor shall be responsible to perform field Hydrostatic test on boilers should State of Illinois or Local Boiler Inspector require it.

3.2 INSTALLATION

A. Install in accordance with all manufacturer's instructions
B. Provide for connection to electrical service.
C. Provide connection of gas service in accordance with ANSI/AGA z223.1.
D. Pipe relief valves to nearest floor drain. Each drain line to be full sized and separately piped to drain.
E. Vents from all gas train components shall terminate individually outdoors through a screened elbow turned down 18 inches above roof or 6 inches from wall and 8 feet above grade and at least 5 feet away from any window, door or air intake. -
F. Install on 4" thick concrete boiler pad as necessary to accommodate new boilers as shown on the drawings.
G. Pipe boiler and boiler flue condensate drains to PH Neutralizing basin per manufacturer’s instructions and to floor drain.

3.3 FIELD QUALITY CONTROL

A. After boiler installation is completed, the manufacturer shall provide the services of a trained and factory certified technician for starting the unit and training the operator.

END OF SECTION

SECTION 15575

BREECHING, CHIMNEYS AND STACKS

PART 1 – GENERAL

1.1 WORK INCLUDED
A. Fabricated breechings.
B. Manufactured chimneys for gas fired equipment.
C. Manufactured double wall chimneys for fuel fired equipment.
D. Vent dampers.

1.2 RELATED SECTIONS
A. Section 15558 – Condensing Firetube Boilers.

1.3 REFERENCES
A. ASTM A167 - Stainless and Heat Resisting Chromium Nickel Steel Plate, Sheet, and Strip.
B. NFPA 54 (ANSI Z223.1) - The National Fuel Gas Code.
C. UL 103 - Standard for Factory Built Low Heat Chimneys.
D. UL 441 - Standard for Gas Vents.
E. UL 641 - Standard for Low Temperature Venting Systems.

1.4 DEFINITIONS
A. Breeching: Vent Connector.
B. Chimney: Primarily vertical shaft enclosing at least one vent for conducting flue gases outdoors.
C. Smoke Pipe: Round, single wall vent connector.
D. Vent: That portion of a venting system designed to convey flue gases directly outdoors from a vent connector or from an appliance when a vent connector is not used.
E. Vent Connector: That part of a venting system that conducts the flue gases from the flue collar of an appliance to a chimney or vent and may include a draft control device.

1.5 SUBMITTALS FOR REVIEW
A. Submit under provisions of the General Requirements.
B. Shop Drawings: Indicate general construction, dimensions, weights, support and layout of breechings. Submit layout drawings indicating plan view and elevations where factory-built units are used.
C. Product Data: Provide data indicating factory-built chimneys, including dimensional details of components and flue caps, dimensions and weights, electrical characteristics and connection requirements.

1.6 QUALITY ASSURANCE
A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum five years documented experience.
B. Installer Qualifications: Company specializing in performing the work of the work of this section with minimum five years documented experience, approved by manufacturer.

1.7 REGULATORY REQUIREMENTS
A. Conform to applicable code for installation of natural gas burning appliances and equipment.
B. Products Requiring Electrical Connection: Listed and classified by Underwriters' Laboratories, Inc., as suitable for the purpose specified and indicated.

PART 2 – PRODUCTS

2.1 DOUBLE WALL METAL STACKS – Category IV
A. Fabricate with 1-inch air space between walls. Liner to be ASTM A 959, type AL29-4C stainless-steel, outer jacket 430 stainless-steel approved for Category IV (Condensing, Positive Pressure) applications.

2.2 ACCEPTABLE MANUFACTURERS:

A. Factory-Built Double Wall Vertical Stacks (Positive Pressure):
   1. Van Packer.
   2. Selkirk Metalbestos.
   3. AMPCO.
   4. Air Management Industries.
   5. MetalFab.
   6. No Substitutions.

2.3 CONSTRUCTION

A. Furnish all items which form a complete assembly including straight sections, tee sections, joint sealant, cleanout door, end capacity drain (1-inch minimum with P-trap designed for minimum 4-inch water seal), full angle ring wall and base supports, insulated roof thimble, roof support assembly, insulated thimble, flashing, counter-flashing, guying where required, Type 316 stainless-steel rain cap.
   1. All sections shall be of double wall construction with minimum 1-inch air space between the liner and the shell.
      a. Note: Outer wall of stack above the roof line shall be Type 316 stainless-steel.

B. Vent sections shall be sealed with banded flanges and silicone joint sealant with a UL tested pressure rating of 40” wc

C. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.
   1. Termination: Velocity Cones

2.4 WARRANTY

A. Contractor shall provide a one (1) year manufacturer’s warranty on parts on furnished equipment. Equipment parts warranty shall start at time of substantial completion. Contractor will provide a one (1) year warranty on all labor associated with the equipment and its’ installation. Warranty shall start at date of final payment. See General Requirements for additional requirements.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install in accordance with NFPA 54 (ANSI Z223.1), NFPA 31.

C. Assemble and install stack sections in accordance with NFPA 82, industry practices, and in compliance with UL listing. Join sections with acid-resistant joint cement to ASTM C105. Connect base section to foundation using anchor lugs.

D. Level and plumb chimney and stacks.

E. Clean breechings, chimneys and stacks during installation, removing dust and debris.

F. At applications, provide slip joints permitting removal of appliance without removal or dismantling of breechings, breeching insulation, chimneys or stacks.

G. Provide minimum length of breeching to connect appliance to chimney.

3.2 OPERATION AND MAINTENANCE DATA BY INSTALLING CONTRACTOR

A. At the completion of the project, the Installing Contractor shall provide furnish two (2) hard copies and two (2) electronic copies of equipment manuals, maintenance manuals and repair parts list for all equipment and systems reviewed. See General Requirements for additional requirements.

END OF SECTION

SECTION 15620

INDOOR CONDENSERLESS LIQUID WATER CHILLER WITH REMOTE CONDENSER (PRE-PURCHASE)

PART 1 - GENERAL

1.1 PRE-PURCHASED EQUIPMENT

A. Kirby School District 140 has elected to pre-bid and purchase the mechanical HVAC equipment called for in this section of the specifications.
B. Equipment will be shipped to Fernway Elementary School at 16600 S. 88th Ave., Orland Park, IL 60463 and will be unloaded by the installing Mechanical Contractor.
C. The equipment manufacturer's representative shall be on site and present at the time of unloading at project site. The Owner's representative, Mechanical Contractor, and manufacturer's representative shall inspect the equipment for damage and/or missing components and identify such in writing.
    1. If there are damaged or missing components, the manufacturer's representative shall provide a written list to the Owner.
    2. A Mechanical Contractor shall inspect the equipment for damage and/or missing components and identify such in writing. If the contractor agrees the equipment is in proper condition, the manufacturer's representative shall obtain a written acceptance of the equipment from the contractor.
D. The equipment manufacturer's bid/proposal includes start-up services. The equipment manufacturer's bid/proposal includes operating manuals and warranty for parts and labor on equipment only. All other warranty services are by the installing contractor.
    1. Owner's schooling shall be provided under this section.
E. All bidding manufacturers must submit complete product data and shop drawings as outlined in sub-section 1.6 below with their bid/proposal, failure to complete submittals with bid/proposal will be grounds for disqualification.

1.2 SECTION INCLUDES

A. Delivery of equipment to the job site with a manufacturer's representative present.
B. Field start-up services and Owner training at the job site.
C. Parts and labor warranty.
D. Chiller package.
E. Controls and control connections
F. Starters.
G. Electrical power connections.
H. Remote air-cooled condensers.

1.3 ASSIGNMENT

A. Equipment will be assigned to the successful mechanical contractor as directed by Owner/Architect/Engineer.

1.4 WORK INCLUDED

A. Delivery of equipment to the job site with a manufacturer's representative present.
B. Parts and labor warranty on Chiller Package from date of delivery.
C. Start-up and Owner's Training on equipment being provided.

1.5 REFERENCES

A. ANSI/ASHRAE STANDARD 15-1992 – Safety Code for Mechanical Refrigeration.
B. ANSI/ARI 550/590-98 – Standard for Water Chilling Packages using the Vapor Compression Cycle.
C. ANSI/ARI 550/590 – Positive displacement compressors and water-cooled rotary screw water – chilling packages
D. ANSI/ASHRAE 90.1 – Energy Efficient Design of New Buildings.
E. ANSI/ASEM SEC 8 – Boiler and Pressure Vessel Code.
F. ANSI/NEMA MG 1 – Motors and Generators.
G. ASHRAE 34 – Number designation and safety classification of refrigerants.
H. ANSI/UL 1995 – Central Cooling Air Conditioners.

I. ANSI/NFPA Standard 70 – National Electric Code (N.E.C.)
J. ANSI/UL 984 – Safety Standards for Hermetic Motor Compressors.
K. Conform to UL Code 1995 for construction of chiller.
L. OSHA – Occupational Safety and Health Act.

1.6 SUBMITTALS

A. Submit two (2) copies of unit performance data including capacity, nominal and operating performance.
B. Submit Mechanical Specifications for unit and accessories describing construction, components, and options.
C. Submit shop drawings indicating overall dimensions as well as installation, operation, and service clearances. Indicate lift points and recommendations and center of gravity. Indicate unit shipping, installation and operating weights including dimensions.
D. Submit data on electrical requirements and connection points. Include recommended wire and fuse sizes or MCA, sequence of operation, safety, and start-up instructions.

1.7 OPERATION AND MAINTENANCE

A. Submit two (2) hard copies and one (1) PDF of manufacturer installation instructions and operation and maintenance data to successful contractor for inclusion in project manual.
B. Include manufacturer's descriptive literature, operating instructions, cleaning procedures, replacement parts list and maintenance and repair data to successful contractor for inclusion in project manual.

1.8 QUALITY ASSURANCE

A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum ten years documented experience.

1.9 REGULATORY REQUIREMENTS

A. Conform to ARI 550/590-98 Standard for testing and certified rating of Water Chilling Packages using the Vapor Compression Cycle.
B. Conform to ANSI/UL 1995 code for construction of water chillers. In the event the unit is not UL approved, the manufacturer shall, at his expense, provide for a field inspection by an UL representative to verify conformance to UL standards. If necessary, contractor shall perform modifications to the unit to comply with UL, as directed by the UL representative.
C. Conform to ANSI/ASME SEC 8 Boiler and Pressure Vessel Code for construction and testing of water chillers.
D. Conform to 2015 International Mechanical Code and 2018 International Energy Conservation Code.

1.10 HANDLING

A. Comply with manufacturer's installation instruction for rigging, unloading, and transporting units.
B. Protect units from physical damage. Leave factory shipping covers in place until installation.

1.11 WARRANTY

A. Provide two (2) year manufacturer's non-prorated warranty on all parts and two (2) year on labor. See General Requirements for additional requirements and start date.
B. Compressor warranty parts only Years 3rd through 5th.
C. Warranty shall include all control components factory mounted on the unit.

PART 2 - PRODUCTS

2.1 MANUFACTURER
A. Carrier.
B. No substitutions.

2.2 GENERAL
A. Factory assembled, single-piece, condenser-less liquid chiller with dual (2) independent refrigerant circuits. Contained within the unit cabinet shall be all factory wiring, piping, controls, and nitrogen holding charge and special features required prior to field start-up. Unit must fit through a standard door. Unit(s) to be provided with refrigerant charge (HFC-134a) in field by installing contractor.

2.3 COMPRESSORS
A. Semi-hermetic twin-screw compressors with internal muffler and check valve.
B. Each compressor shall be equipped with a discharge shutoff valve.

2.4 COOLER (EVAPORATOR)
A. Shall be tested and stamped in accordance with ASME Code for a refrigerant working-side pressure of 220 psig. Water-side pressure rating shall be 300 psig.
B. Shall be mechanically cleanable shell-and-tube type with removable heads.
C. Tubes shall be internally enhanced, seamless-copper type, and shall be rolled into tube sheets. Tube wall thickness shall be 0.025 inches.
D. Shell shall be insulated with 3/4-in. closed-cell, polyvinyl chloride foam with a maximum K factor of 0.28. Heads may require field insulation.
E. Shall have a cooler drain and vent.
F. Design shall incorporate 2 independent refrigerant circuits.
G. Shall include isolation valves to allow isolation of the refrigerant charge in either the evaporator or the condenser.
H. Shall be equipped with factory-installed thermal dispersion chilled fluid flow switch.

2.5 OIL SEPARATOR
A. Shall be tested and stamped in accordance with ASME Code for a refrigerant working-side pressure of 320 psig.
B. Design shall incorporate 2 independent refrigerant circuits.

2.6 REFRIGERATION COMPONENTS
A. Refrigerant circuit components shall include oil separator, high and low side pressure relief devices, discharge and liquid line shutoff valves, filter drier, strainer, moisture indicating sight glass, expansion valve, refrigerant economizer, and complete charge of compressor oil. Units shall have a holding charge of nitrogen.

2.7 CONTROLS, SAFETIES AND DIAGNOSTICS
A. Controls:
   1. Unit controls shall include the following minimum components:
      a. BACnet over MSTP communication with a gateway.
      b. Microprocessor with non-volatile memory. Battery backup system shall not be accepted.
      c. Power and control circuit terminal blocks.
      d. ON/OFF control switch.
      e. Replaceable solid-state relay panels.
      f. Thermistor installed to measure saturated condensing temperature, cooler saturation temperature, compressor return gas temperature, and cooler entering and leaving fluid temperatures.
      g. Chilled fluid thermal dispersion flow switch.

2. Unit controls shall include the following functions as standard:
   a. Automatic circuit lead/lag.
   b. Capacity control based on leaving chilled fluid temperature and compensated by rate of change of return-fluid temperature with temperature set point accuracy to 0.1 ° F.
   c. Limiting the chilled fluid temperature pull-down rate at start-up to an adjustable range of 0.2° F to 2° F per minute to prevent excessive demand spikes at start-up.
   d. Seven-day time schedule.
   e. Chilled and condenser water pump start/stop control.
   f. Dual chiller control for series chiller applications without addition of hardware modules or additional thermistors.
   g. Dual chiller control for parallel flow applications use one additional sensor.
   h. Amperage readout per compressor with %MTA (must trip amps) per compressor.
3. NEMA 1 control panel shall include, as standard, a portable hand-held display module with a minimum of 4 lines and 20 characters per line, of clear English, Spanish, Portuguese or French language. Display menus shall provide clear language descriptions of all menu items, operating modes, configuration points and alarm diagnostics. Reference to factory codes shall not be accepted. An industrial grade coiled extension cord shall allow the display module to be moved around the chiller. Magnets shall hold the display module to any sheet metal panel to allow hands-free operation. Display module shall have NEMA 4x housing suitable for use in outdoor environments. Display shall have back light and contrast adjustment for easy viewing in bright sunlight or night conditions. The display module shall have raised surface buttons with positive tactile response.
4. The chiller controller shall include multiple connection ports for communicating with the local equipment network and the ability to access all chiller control functions from any point on the chiller.
5. The control system shall allow software upgrade without the need for new hardware modules.
6. Provide provisions for the following hard-wired points:
   a. Chiller Enable/Disable.
   b. Chiller Status.
   c. Chiller Alarm.
   d. Chiller Reset (0-10 volt).
7. Provide one BACnet controller for each chiller.

B. Safeties:

Unit shall be equipped with thermistors and all necessary components in conjunction with the control system to provide the unit with the following protections:

1. Loss of refrigerant charge.
2. Reverse rotation.
3. Low chilled fluid temperature.
4. Low oil pressure (each compressor circuit).
5. Ground current fault.
6. Thermal overload.
7. High pressure.
8. Electrical overload.
9. Loss of phase.
10. Current imbalance.
11. Loss of flow.

C. Diagnostics:

1. The display module shall be capable of indicating the safety lockout condition by displaying the information in clear language at the display. Information included for display shall be:
   a. Compressor lockout.
   b. Loss of charge.
   c. Low fluid flow.
   d. Low oil pressure.

e. Cooler freeze protection.
f. High or low suction superheat.
g. Thermistors malfunction.
h. Entering and leaving-fluid temperature.
i. Evaporator and condenser pressure.
j. Electronic expansion valve positions.
k. All set points.
l. Time of day.

2. Display module, in conjunction with the microprocessor, must also be capable of displaying the output results of a service test. Service test shall verify operation of every switch, thermistor, and compressor before chiller is started. User shall be able to force each output device.
3. Diagnostics shall include the ability to review a list of the 20 most recent alarms with clear language descriptions of the alarm event. Display of alarm codes without the ability for clear language descriptions shall be prohibited.
4. An alarm history buffer shall allow the user to store no less than 20 alarm events with clear language descriptions, time, and date stamp event entry.

D. Operating Characteristics:
Unit shall be capable of starting up with 95 F entering fluid temperature to the cooler.

E. Electrical Requirements:
1. Unit primary electrical power supply shall enter the unit at a single location (some units have multiple power poles).
2. Unit shall operate on 3-phase power at the voltage shown in the equipment schedule.
3. Control voltage shall be 115-v (60 Hz), single-phase, separate power supply by mechanical contractor.
4. Unit shall be shipped with factory control and power wiring installed.

F. Special Features:
1. Wye-Delta Starter:
2. Unit shall have a factory-installed, Wye-Delta starter to minimize electrical inrush current.
3. Vibration Isolation:
4. Chiller manufacturer shall furnish neoprene isolator pads for mounting equipment on a level, concrete surface.
5. Control Power Transformer:
6. Unit shall be supplied with a field-installed transformer that will supply control circuit power from the main unit power supply.
7. Temperature Reset Sensor:
8. Unit shall reset leaving chilled fluid temperature based on outdoor ambient temperature or space temperature when this sensor is installed.
9. Minimum Load Control:
10. Unit shall be equipped with factory (or field) installed, microprocessor-controlled, minimum load control that shall permit unit operation down to 10% of full capacity.
11. Chiller System Manager:
12. Control shall enable management of multiple parallel chillers (up to 8) or two (2) chillers in series in a single system.
13. Suction Service Valves:
14. Unit shall be supplied with factory-installed suction service valves to isolate compressor from evaporator and condenser.
15. Cooler Head Insulation:
16. Unit shall be supplied with field-installed cooler insulation that shall cover the cooler heads.
17. BACnet Communication: Shall provide factory installed communication capability with a BACnet MS/TP network.

2.8 ACCESSORIES AND OPTIONS

A. Power Supply Connections (Factory Mounted):
   1. Single Point Circuit Breaker: Single point Terminal Block with Circuit Breaker and lockable external handle (in compliance with Article 0 1 of N.E.C.) can be supplied to isolate power voltage for servicing. Incoming power wiring must comply with the National Electric Code and/or local codes.

B. Flow Switch (Field-mounted): Vapor proof SPDT, NEMA 3R switch (150 PSIG), -20°F to 250°F. Available with evaporator.

C. Hot Gas By-Pass (Factory Mounted): Permits continuous, stable operation at capacities below the minimum step of unloading to as low as 5% capacity (depending on both the unit & operating conditions) by introducing an artificial load on the evaporator. Hot gas by-pass is installed on only one refrigerant circuit (System #2).

D. Final Paint Overspray: Overspray painting of assembled unit with factory enamel.

2.9 AIR COOLED CONDENSER(S)

A. Legs: Heavy-gauge galvanized steel with foot pads and mounting holes on the bottom of each leg.

B. Coil: Seamless copper tubes are expanded into full-collar aluminum fins. Fins have a corrugated surface to create high air-side heat transfer. Fin edges are rippled to work harden and stiffen material for resistance to mechanical damage. Return bends and headers are brazed with highly ductile silver-bearing copper alloy. Coil casings and tubesheets are manufactured from galvanized steel. The tubesheets include aluminum inserts to prevent wear at the juncture of the tubes and tubesheets.
   1. Prior to shipment, coils are pressure tested, dehydrated, evacuated, pressurized with dry air or nitrogen, and sealed.
   2. 3/8 in. OD tubes are used in coils up to four-fan lengths. 1/2 in. OD tubes are used in five- and six-fan lengths. The 3/8 in. OD tube coils are available with a 650-psig design pressure for up to 250°F refrigerant inlet temperature for R-410A condensing and are pressure tested at 650 psig with dry air. The 1/2 in. OD tube coils have a 360-psig design pressure for up to 250°F refrigerant inlet temperature. They are tested at 450 psig with dry air.

C. Headers: Heavy-wall copper tube headers are designed for low pressure loss and proper refrigerant distribution. Multiple-circuit condensers feature completely separate headers for each system circuit so there is no danger of refrigerant leaking between circuits. Gas inlet and liquid outlet connections are provided. Integral sub-cooling is available.

D. Housing: Heavy-gauge galvanized steel panels are assembled with high-tensile fasteners. Fan panels have long, smooth-radius outlet orifices to ensure high efficiency and low noise level.

E. Fan Guards: Heavy-gauge OSHA accepted fan guard design uses wire and rod treated to resist rust and corrosion.

F. Fans: High-efficiency, high-strength airfoil-profile blade fans are used for low noise and energy-efficient performance.

G. Motors: Open, air-over motors have built-in thermal overload protection. They can be started or cycled from a contactor.

H. Motor Mounts: Heavy-gauge galvanized steel channels are used to mount motors.

I. Motor Wiring: Motors are wired to contactors located in a UL-listed, NEMA 3R, weather-resistant enclosure, which includes a non-fused disconnect switch, motor fuses, contactors, and an integral 115V control transformer. Double-wide units have motors wired in pairs. Enclosure ships mounted.

J. Accessories and Options
   1. Sealtite Conduit – All fan motor wiring enclosed in sealed conduit.
   2. Steel Flanged Connections – Headers are available with horizontal connections with steel flanges.

3. Head Pressure Control by Temperature (For ambient temperatures down to 40°F) – Motors are wired to contactors located in a UL-listed, NEMA 3R, weather-resistant enclosure with temperature-controlled fan-cycling to extend operation to 40°F minimum ambient. - Enclosure includes non-fused disconnect switch, motor fuses, contactors and integral 115V control transformer. Enclosure ships mounted. Included temperature sensors must be field installed. No use of receivers is required.

2.10 MANUFACTURER'S FIELD SERVICES

A. A. Chiller manufacturer shall furnish a factory trained service engineer without additional charge to start the units. Chiller manufacturer shall maintain service capabilities to more than 100 miles from the jobsite.
B. B. The manufacturer shall furnish complete submittal wiring diagrams of the chiller as applicable for field maintenance and service.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer’s instructions.
B. Install and align chiller package on concrete foundations.
C. Install units on wafer pads. Refer to Section 15245.
D. Connect to electrical service. Refer to Section 16180.
E. Connect to chilled water piping. Refer to Section 15510.
    1. On inlet, provide:
        a. Thermometer well for temperature controller.
        b. Thermometer well or temperature limit controller.
        c. Flexible pipe connector.
        d. Shut-off valve.
        e. Temperature gauge.
    2. On outlet, provide:
        a. Flexible pipe connector.
        b. Shut-off valve.
        c. Temperature gauge.
F. Arrange piping for easy dismantling to per tube cleaning.
G. Install with all manufacturer’s recommended clearances and per installation instructions.
H. All gauges located on the exterior shall be suitable for exterior application.
I. Connect to refrigerant piping from chiller to condenser. Refer to Section 15535.
    1. Provide all manufacturer required refrigeration specialties.
    2. Install all manufacturer provided loose refrigeration specialties.
J. Install condenser on roof on mechanical contractor supplied 18” high platform curb as indicated on contract drawings.
K. Test all refrigerant piping and evacuate for charging.
L. Supply initial charge of refrigerant and oil.
M. Provide and install relief valves per chiller manufacturer.
N. Contractor to install all loose sound blankets/insulation provided by chiller manufacturer.
O. Contractor to provide field electrical power to controls and/or control transformer.
P. Contractor to field insulate chiller bundle heads.

3.2 REQUIREMENTS BY INSTALLING CONTRACTOR

A. Contractor shall furnish two (2) hard copies and two (2) electronic copies of equipment manuals, maintenance manuals and repair parts list for all equipment and systems reviewed. See General Requirements for additional requirements

END OF SECTION

SECTION 15671

AIR COOLED CONDENSING UNITS

PART 1 – GENERAL

1.1 SECTION INCLUDES
A. Condensing unit package.
B. Charge of refrigerant and oil.
C. Controls and control connections.
D. Refrigerant piping connections.
E. Motor starters.
F. Electrical power connections.
G. Platform roof curb or concrete base.

1.2 RELATED SECTIONS
A. Section 15245 - Vibration Isolation.
B. Section 15535 - Refrigerant Piping and Specialties.
C. Section 15855 – Air Handling Units.
D. Division 17 - Building Automation System.

1.3 REFERENCES
A. ARI 370 - Sound Rating of Large Refrigeration and Air-Conditioning Equipment.
B. ARI 360 - Unitary Air Conditioning Equipment.
C. ASHRAE 14 - Methods of Testing for Rating Positive Displacement Condensing Units.
D. ASHRAE 15 - Safety Code for Mechanical Refrigeration.
E. ASHRAE 90A - Energy Conservation in new Building Design.
F. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
G. NEMA MG 1 - Motors and Generators.
H. UL 207 - Refrigerant Containing Components and Accessories, Non-Electrical.
I. UL 303 - Refrigeration and Air Conditioning Condensing, and Air Source Heat Pump Equipment.

1.4 SUBMITTALS
A. Submit under provisions of Division 1 General Requirements.
B. Shop Drawings: Indicate components, assembly, dimensions, weights and loadings, required clearances, and location and size of field connections. Include schematic layouts showing condensing units, cooling coils, refrigerant piping, and accessories required for complete system.
C. Product Data: Provide rated capacities, weights, specialties and accessories, electrical nameplate data, and wiring diagrams.
D. Design Data: Indicate refrigeration pipe and equipment sizing.
E. Submit manufacturer's installation instructions.
F. Operation and Maintenance Data: Submit under provisions of Division 1 General Requirements.
G. Operation and Maintenance Data: Include manufacturer’s descriptive literature, startup instructions, maintenance instructions, parts lists, controls, and accessories.

1.5 REGULATORY REQUIREMENTS
A. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.
B. Unit shall conform to UL 1995/CSA 22.2 #236 for construction of condensing units and shall have UL/CSA label affixed to unit.

1.6 DELIVERY, STORAGE, AND PROTECTION
A. Transport, handle, store, and protect products under provisions of Division 1 General Requirements.
B. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.

C. Protect units on site from physical damage. Protect coils.
D. Contractor shall store all materials shipped to the site in a protected area. If material is stored outside of the building, it must be stored off the ground a minimum of six inches set on 6 x 6 planks and/or wood pallets. All material must be completely covered with waterproof tarps or visqueen. All piping will have the ends closed to keep out dirt and other debris. No equipment will be allowed to be stored on the site unless it is sitting on wood planks and is completely protected with weatherproof covers.

1.7 ACOUSTICS

A. Manufacturer of condensing unit shall provide outdoor sound power level data across all major octave band center frequencies for cataloged operating range of unit at gross cooling capacity range. Data shall be obtained in conformance with ANSI S1.32-1980, American National Standard Methods for the Determination of Sound Power Levels of Discrete Frequency and Narrow Band Noise Sources in Reverberation Rooms and per AMCA Standard 300-85 test code "Sound Rating Air Moving Devices".

1.8 WARRANTY

A. Provide one (1) year parts and labor warranty for the entire package.
B. Provide a five (5) year parts and labor warranty to include coverage for refrigerant compressors.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

A. Carrier.
B. No substitutions.

2.2 MANUFACTURED UNITS

A. Units: Self-contained, packaged, factory assembled and pre-wired units suitable for outdoor use consisting of cabinet, compressors, condensing coil and fans, sub cooling circuits, controls, and liquid receiver.
B. Construction and Ratings: In accordance with ARI 360 and UL 1995. Testing shall be in accordance with ASHRAE 14.
C. Performance Ratings: Performance as scheduled on Drawings. Energy Efficiency Rating (EER) and Coefficient of Performance (COP) not less than prescribed by ASHRAE 90A. Operating range shall be between 115º F and 35º F.

2.3 CASING

A. Unit casing shall be constructed of 18-gauge zinc coated heavy gauge, galvanized steel. Exterior surfaces shall be cleaned, phospatized and finished with a weather-resistant baked enamel finish. Unit’s surface shall be tested 500 hours in salt spray test. Units shall have removable end panels, which allow access to all major components and controls.

2.4 CONDENSER SECTION

A. Coils shall be internally finned or smooth bore 3/8" copper tubes mechanically bonded to configured aluminum plate fin as standard. Factory pressure and leak tested to 425 psig air pressure. Metal grilles with PVC coating for coil protection shall be provided.

2.5 REFRIGERATION SYSTEM – DUAL COMPRESSOR

A. Units shall have two separate and independent refrigeration circuits. Each refrigeration circuit shall have an integral sub-cooling circuit. A refrigeration filter drier shall be provided. Units shall have both a liquid line and suction gas line service valve with gauge port.

B. Units shall have two direct-drive hermetic reciprocating compressors with centrifugal oil pump and provide positive lubrication to all moving parts. Motor shall be suction gas-cooled and shall have a voltage utilization range of plus or minus 10 percent of nameplate voltage. Crankcase heater, internal temperature and current-sensitive motor overloads shall be included for maximum protection. Units shall have internal spring isolation and sound muffling to minimize vibration transmission and noise. External high and low-pressure cutout devices shall be provided. Evaporator defrost control provided in indoor blower coil shall prevent compressor slugging by temporarily interrupting compressor operation when low evaporator coil temperatures are encountered.

2.6 FANS AND MOTORS

A. Direct-drive, statically and dynamically balanced propeller fan(s) with aluminum blades and electro-coated steel hubs shall be used in draw-through vertical discharge position. Either permanently lubricated totally enclosed or open construction motors shall be provided and shall have built in current and thermal overload protection. Motor(s) shall have be either ball or sleeve bearing type.

2.7 CONTROLS

A. Condensing units shall be completely factory wired with necessary controls and contactor pressure lugs or terminal block for power wiring. Control wiring shall be 24-volt control circuit, which includes fusing and control transformer. Units shall provide external location for mounting a fused disconnect device. Time delay timers to prevent compressors in dual compressor units from simultaneous start-up and anti-recycle timers shall be provided.

2.8 MISCELLANEOUS FEATURES

A. Vibration Isolation Packages – Shall reduce transmission of noise and vibration to building structures, equipment and adjacent spaces. Packages shall be available in either neoprene-in-shear or spring-flex types.
B. Hot Gas Bypass Kit – Shall be available to provide capacity modulation.
C. Time Delay Relay – Shall prevent compressors in dual compressor unit from coming on line simultaneously. Timer shall be 24-volt, 60-cycle, with four-minute timing period.
D. Anti-Short Cycle Timer – Shall prevent rapid on-off compressor cycling in light load conditions by not allowing compressor to operate for 5-7 minutes upon shutdown. Shall consist of a solid-state timing device, 24-volt, 60-cycle with either 5 or 7 minute fixed-off timing period.
E. Condenser Coil Guard – Metal grille with PVC coating shall be provided to alleviate coil damage.
F. Platform Roof Curb – 18” high. See details.
G. Hail guard.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.
B. Provide for connection to electrical service.
C. Install units on vibration isolation.
D. Install units on roof 18” high platform curb as indicated on contract documents.
E. Provide connection to refrigeration piping system and evaporators.
F. See Section 15242 – Vibration Isolation for additional requirements.

3.2 MANUFACTURER'S FIELD SERVICES

A. Supply initial charge of refrigerant and oil for each refrigerant circuit.
B. Manufacturer shall furnish a factory trained service engineer without additional charge to start the units. Package rooftop unitary manufacturers shall maintain service capabilities no more than 100 miles from the job site.
C. The manufacturer shall furnish complete submittal wiring diagrams of the package unit as applicable for field maintenance and service.

3.3 REQUIREMENTS BY INSTALLING CONTRACTOR

A. Contractor shall furnish a minimum of two (2) equipment manuals, maintenance manuals and repair parts list for all equipment and systems reviewed.

END OF SECTION

SECTION 15775

KITCHEN HOODS

PART 1 – GENERAL

1.1 SECTION INCLUDES
A. Kitchen Hoods
B. Controls

1.2 RELATED WORK
A. Section 15290 – Ductwork Insulation.
B. Section 15870 – Power Ventilators
C. Section 15890 – Ductwork.

1.3 SUBMITTALS
A. Product Data: For the following:
   1. Hoods.
   2. Grease removal devices.
B. Shop Drawings: Signed and sealed by a qualified professional engineer.
   1. Show plan view, elevation view, sections, roughing-in dimensions, service requirements, duct connection sizes, and attachments to other work.
   2. Show cooking equipment plan and elevation to confirm minimum code-required overhang.
   3. Indicate performance, exhaust and makeup air airflow and pressure loss, at actual Project Site elevation.
   4. Indicate method of attaching hangers to building structure.
   5. Show control cabinets.
   6. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
   7. Design Calculations: Calculate requirements for selecting seismic restraints.
   8. Wiring Diagrams: Power, signal, and control wiring.
C. Coordination Drawings: Reflected-ceiling plans drawn to scale and coordinating penetrations and ceiling-mounted items. Show the following:
   1. Relative location of ceiling-mounted items including lighting fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings to hoods and accessory equipment.
   2. Roof framing and support members for duct penetrations.
   3. Ceiling suspension assembly members.
   4. Size and location of initial access modules for acoustical tile.
D. Welding certificates.
E. Field test reports.

1.4 QUALITY ASSURANCE
A. Engineering Responsibility: Preparation of Shop Drawings and comprehensive engineering analysis by a qualified professional engineer.
B. Welding: Qualify procedures and personnel according to AWS D1.1, "Structural Welding Code--Steel," for hangers and supports; and AWS D9.1, "Sheet Metal Welding Code," for joint and seam welding.
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. NSF Compliance: Fabricate hoods according to NSF 2, "Food Equipment."
E. SMACNA Compliance:
   1. Comply with SMACNA's "Kitchen Equipment Fabrication Guidelines," Appendix 1, "Guidelines for Seismic Restraints of Kitchen Equipment."
   2. Fabricate hoods to comply with SMACNA's "HVAC Duct Construction Standards: Metal and Flexible," second edition.

1.5 PROJECT CONDITIONS

A. Field Measurements: Verify dimensions of food service equipment installation areas by field measurements before fabrication and indicate measurements on Shop Drawings.
   1. Established Dimensions: Where field measurements cannot be made without delaying the Work, establish required dimensions using approved food facility equipment Shop Drawings. Coordinate fabrication with food facility equipment manufacturer to ensure that actual dimensions correspond to established dimensions.

1.6 COORDINATION

A. Coordinate equipment layout and installation with other Work, including light fixtures, HVAC equipment, and fire-suppression system components.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

A. Halton.
B. KEES - Model KA.
C. Owner Approved Equal.

2.2 REQUIREMENTS

A. Furnish and install a complete kitchen exhaust canopy system. The canopy shall bear the Underwriters Laboratories (U.L.) label, UL (or ETL) listed range hood without exhaust fire damper per standard 710 and be fabricated in compliance with NFPA-96 standards and shall bear the National Sanitation Foundation (NSF) seal of approval.
B. The installation shall be in accordance with manufacturer's recommendations and conform to NFPA-96 guidelines and all applicable local codes.
C. The size shall be as indicated on the drawings and/or equipment schedule.

2.3 HOOD MATERIALS

A. The outer canopy shall be 18-gauge stainless steel, where exposed, type 304 with No. 3 polish finish.
   1. Canopy ends shall be double wall construction. All exterior joints shall be continuously welded liquid tight, ground smooth, and polished to a No. 3 polish finish as specified below.
B. The inner canopy liner shall be 18-gauge stainless steel, where exposed, type 304 with No. 3 polish finish.
   1. The canopy shall have an integral exhaust duct collar(s). All seams of the inner liner shall have grease tight joints (UL).
   2. Filter housing shall be of the same material as the canopy liner and shall be equipped with a concealed drip tray the full length of the canopy and with a stainless-steel grease cup for easy removal and daily cleaning.
   3. Lights shall be U.L. listed LED type, suitable for grease hoods. Pre-wired to a junction box on top of hoods. Wiring shall conform to National Electric Code.
C. Hood shall be provided with a minimum of four connections for hanger rods. Connectors shall have 9/16" holes pre-punched in 1 ½" x 1 ½" angle iron at the factory to allow for hanger rod connection by others.

D. The hood shall be furnished with U.L. classified filters, supplied in size and quantity as required by ventilator. The filters shall extend the full length of the hood. Filter shall be constructed of stainless steel and aluminum. Provide filter/baffle grease filters with spring-loaded fastening. Provide filter removal tool. The grease extraction efficiency is 93% on particles with a diameter of 5 microns and 98% on particles with a diameter of 15 microns or larger, as tested to an ASTM F-2519 standard test protocol by an independent testing laboratory. The pressure loss over the extractor shall not exceed 0.50” w.c. at flow rates approved by UL for heavy load cooking. Sound levels shall not exceed an NC rating of 55. Air flows through the extractors and air chamber are to be determined through the integral testing and balancing ports mounted on the hood. The airflows are to be determined by the pressure vs. airflow curves supplied by the hood manufacturer.
E. The hood manufacturer shall supply complete computer-generated submittal drawings including hood sections view(s) and hood plan view(s). These drawings must be available to the engineer, architect and owner for their use in construction, operation and maintenance.
F. Exhaust duct collar(s) to be 3" high with 3/4" flange, continuously welded to top of hood an at corners. Duct sizes, CFM and static pressure requirements shall be as shown on drawings. Static pressure requirements shall be precise and accurate; air velocity and volume information shall be accurate within 1-ft increments along the length of the ventilator.

2.4 HOOD FABRICATION

A. Welding: Use welding rod of same composition as metal being welded. Use methods that minimize distortion and develop strength and corrosion resistance of base metal. Make ductile welds free of mechanical imperfections such as gas holes, pits, or cracks.
   1. Welded Butt Joints: Full-penetration welds for full-joint length. Make joints flat, continuous, and homogenous with sheet metal without relying on straps under seams, filling in with solder, or spot welding.
   2. Grind exposed welded joints flush with adjoining material and polish to match adjoining surfaces.
   3. Where fasteners are welded to underside of equipment, finish reverse side of weld smooth and flush.
   4. Coat concealed stainless-steel welded joints with metallic-based paint to prevent corrosion.
B. For metal butt joints, comply with SMACNA's "Kitchen Equipment Fabrication Guidelines."
C. Where stainless steel is joined to a dissimilar metal, use stainless-steel welding material or fastening devices.
D. Form metal with break bends that are not flaky, scaly, or cracked in appearance; where breaks mar uniform surface appearance of material, remove marks by grinding, polishing, and finishing.
E. Sheared Metal Edges: Finish free of burrs, fins, and irregular projections.
F. In food zones, as defined in NSF, fabricate surfaces free from exposed fasteners.
G. Cap exposed fastener threads, including those inside cabinets, with stainless-steel lock washers and stainless-steel cap (acorn) nuts.
H. Fabricate pipe slots on equipment with turned-up edges sized to accommodate service and utility lines and mechanical connections.
I. Fabricate enclosures, including panels, housings, and skirts, to conceal service lines, operating components, and mechanical and electrical devices including those inside cabinets, unless otherwise indicated.
J. Fabricate seismic restraints according to SMACNA's "Kitchen Equipment Fabrication Guidelines," Appendix 1, "Guidelines for Seismic Restraints of Kitchen Equipment."
K. Fabricate equipment edges and backsplashes according to SMACNA's "Kitchen Equipment Fabrication Guidelines."

L. Fabricate enclosure panels to ceiling and wall as follows:
   1. Fabricate panels on all exposed sides with same material as hood, and extend from ceiling to top of hood canopy and from canopy to wall.
   2. Wall Offset Spacer: Minimum of 3 inches.
   3. Wall Shelves and Overshelves: Fabricate according to SMACNA's "Kitchen Equipment Fabrication Guidelines," with minimum 0.0625-inch-thick, stainless steel shelf tops.
M. Weld all joints exposed to grease with continuous welds and make grease removal devices and makeup air diffusers easily accessible for cleaning.
   1. Hood shall be listed and labeled, according to UL 710, by a testing agency acceptable to authorities having jurisdiction.
   2. Include access panels as required for access to fire dampers and fusible links.
N. Provide hood skirt to close-off hood to ceiling; field verify.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting installation.
B. Examine roughing-in for piping systems to verify actual locations of piping connections before equipment installation.
C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Install hoods level and plumb.
B. Complete field assembly of hoods where required.
   1. Make closed butt and contact joints that do not require filler.
   2. Grind field welds on stainless-steel equipment smooth, and polish to match adjacent finish. Comply with welding requirements in Part 2 "General Hood Fabrication" Article.
C. Install hoods and associated services with clearances and access for maintaining, cleaning, and servicing hoods, grease removal devices, and fire-suppression systems according to manufacturer's written instructions and requirements of authorities having jurisdiction.
D. Make cutouts in hoods where required to run service lines and to make final connections.
E. Securely anchor and attach items and accessories to walls, floors, or bases with stainless-steel fasteners, unless otherwise indicated.
F. Install hoods to operate free from vibration.
G. Install seismic restraints according to SMACNA's "Kitchen Equipment Fabrication Guidelines," Appendix 1, "Guidelines for Seismic Restraints for Kitchen Equipment."
H. Install trim strips and similar items requiring fasteners in a bed of sealant. Fasten with stainless steel fasteners at 48 inches o.c. maximum.
I. Install sealant in joints between equipment and abutting surfaces with continuous joint backing, unless otherwise indicated. Provide airtight, watertight, vermin-proof, sanitary joints.
J. Install lamps, with maximum recommended wattage, in equipment with integral lighting.
K. Install hood skirt.

3.3 CONNECTIONS

A. Piping installation requirements are specified in other Division 15 and 16 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
B. Install piping adjacent to machine with clearance to allow service and maintenance.
C. Duct Connections: Comply with applicable requirements in Division 15 Section "Ductwork" for flexible connectors on makeup air supply duct. Weld exhaust-duct connections.
D. Ground equipment.
E. 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.

3.4 FIELD QUALITY CONTROL

A. Testing: Owner will engage a qualified testing agency to perform the following field quality control testing.
B. Testing: See Section 17800 - Testing, Adjusting and Balancing.
C. Testing: Engage a qualified testing agency to perform the following field quality-control testing.
D. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.
    1. Test each equipment item for proper operation. Repair or replace equipment that is defective, including units that operate below required capacity or that operate with excessive noise or vibration.
    2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
    3. Test motors and rotating equipment for proper rotation and lubricate moving parts according to manufacturer's written instructions.
    4. Test liquid-carrying and water, drain, and gas components for leaks. Repair or replace leaking components.
E. Remove malfunctioning units, replace with new units, and retest as specified above.

3.5 ADJUSTING

A. Set initial temperatures and calibrate sensors.
B. Set field-adjustable switches.

3.6 CLEANING

A. Remove protective coverings and clean and sanitize hoods and associated services, both inside and out, according to manufacturer’s written instructions.
B. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.

END OF SECTION

SECTION 15790

AIR COILS

PART 1 – GENERAL

1.1 WORK INCLUDED
A. Water coils.

1.2 RELATED SECTIONS
A. Section 15260 - Piping Insulation.
B. Section 15510 - Hydronic Piping.
C. Section 15515 - Hydronic Specialties.
D. Section 15890 - Ductwork: Installation of duct coils.
E. Division 17 - Building Automation System.

1.3 REFERENCES
A. ARI 410 - Forced Circulation Air Cooling and Air Heating Coils.
B. SMACNA - HVAC Duct Construction Standards, Metal and Flexible.
C. NFPA 70 - National Electrical Code.

1.4 SUBMITTALS FOR REVIEW
A. Submit under provisions of Division 1 General Requirements.
B. Product Data: Provide coil and frame configurations, dimensions, materials, rows, connections, and rough in dimensions.
C. Shop Drawings: Indicate coil and frame configurations, dimensions, materials, rows, connections, and rough in dimensions.

1.5 QUALITY ASSURANCE
A. Manufacturer Qualifications: Company specializing in manufacturing the Products specified in this section with minimum ten years documented experience.

1.6 REGULATORY REQUIREMENTS
A. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.

1.7 DELIVERY, STORAGE, AND HANDLING
A. Transport, handle, store and protect products in accordance with Division 1 General Requirements.
B. Protect coil fins from crushing and bending by leaving in shipping cases until installation, and by storing indoors.
C. Protect coils from entry of dirt and debris with pipe caps or plugs.

1.8 WARRANTY
A. Contractor shall provide a one (1) year manufacturer’s warranty on parts on furnished equipment. Equipment parts warranty shall start at time of substantial completion. Contractor will provide a one (1) year warranty on all labor associated with the equipment and its’ installation. Warranty shall start at date of final payment. See General Requirements for additional requirements.
B. Provide five-year extended manufacturer warranty for coils. (Parts only).

PART 2 – PRODUCTS

2.1 WATER HEATING AND COOLING COILS
A. Manufacturers:
   1. Carrier.
   2. No substitutions.
B. Tubes: 5/8-inch OD x 0.025 wall seamless copper arranged in parallel or staggered pattern, expanded into fins, silver brazed joints.

C. Fins: Aluminum continuous plate type with full fin collars or individual helical finned tube type wound under tension, 0.008” aluminum.
D. Casing: Die formed channel frame of 16-gauge stainless steel with 3/8-inch mounting holes on 3-inch centers. Provide tube supports for coils longer than 36-inches.
E. Headers: Stainless steel with tubes expanded into header.
F. Testing: Air test under water to 350 psig for working pressure of 200 psig and 220 degrees F.
G. Configuration: Drainable, serpentine type with return bends on smaller sizes and return headers on larger sizes.
H. Fin Spacing: As shown on drawings.
I. Mount cooling coils on contractor fabricated stainless steel support rack to permit coils to slide out individually from coil bank.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturers written instructions.
B. Install in ducts and casings in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible.
   1. Support coil sections independent of piping on steel channel or double angle frames and secure to casings.
   2. Provide frames for maximum three coil sections.
   3. Arrange supports to avoid piercing drain pans.
   4. Provide airtight seal between coil and duct or casing.
   5. Refer to Section 15890.
C. Protect coils to prevent damage to fins and flanges. Comb out bent fins.
D. Install coils level.
E. Make connections to coils with unions and flanges.
F. Hydronic Coils:
   1. Hydronic Coils: Connect water supply to leaving airside of coil.
   2. Provide shut off valve on supply line and lock shield balancing valve with memory stop on return line.
   3. Locate water supply at bottom of supply header and return water connection at top.
   4. Provide air vents at high points complete with stop valve.
   5. Ensure water coils are drainable and provide drain connection at low points.
   6. Provide new drain pans where coils are installed in existing air supply units.
   7. Refer to Section 15515.
G. Insulate headers located outside airflow as specified for piping. Refer to Section 15260.
H. Provide intermediate tube support for all coils over 44” fin length, with an additional support every 42” multiple thereafter.

END OF SECTION

SECTION 15836

TERMINAL HEAT TRANSFER UNITS – HOT WATER

PART 1 – GENERAL

1.1 SECTION INCLUDES
A. Horizontal and vertical pipe enclosures.
B. Hydronic Finned Tube Radiation
C. Suspended unit heaters.
D. Cabinet unit heaters.
E. Fan coil units.

1.2 RELATED SECTIONS
A. Section 15510 - Hydronic Piping.
B. Section 15515 - Hydronic Specialties.
C. Division 17 - Building automation system.

1.3 REFERENCES
A. NFPA 70 - National Electrical Code.
B. International Mechanical Code 2015.

1.4 SUBMITTALS FOR REVIEW
A. Product Data: Provide typical catalog of information including arrangements.
B. Shop Drawings:
   1. Indicate cross sections of cabinets, grilles, bracing and reinforcing, and typical elevations.
   2. Submit schedules of equipment and enclosures typically indicating length and number of pieces of element and enclosure, corner pieces, end caps, cap strips, access doors, pilaster covers, and comparison of specified heat required to actual heat output provided.
   3. Indicate mechanical and electrical service locations and requirements.
C. Submit under provisions of Division 1 General Requirements.
D. Indicate capacity and dimensions of manufactured products and assemblies required for this project. Indicate electrical service with electrical characteristics and connection requirements, and duct connections.
E. Submit manufacturer's installation instructions. Indicate assembly, support details, connection requirements, and include start-up instructions.
F. Contractor shall review all shop drawings prior to submitting them for Architect/ Engineer's review. Contractor shall stamp each shop drawing to certify that the has reviewed it. Engineer will not check shop drawings that contractor has not stamped with his review certification.

1.5 SUBMITTALS AT PROJECT CLOSEOUT
A. Project Record Documents: Record actual locations of components and locations of access doors in radiation cabinets required for access or valving.
B. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listings.
C. Warranty: Submit manufacturer warranty and ensure forms have been completed in Owners name and registered with manufacturer.

1.6 REGULATORY REQUIREMENTS
A. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.
B. Conform to 2015 International Mechanical Code.

1.7 WARRANTY
A. Contractor shall provide a one (1) year manufacturer's warranty on parts on furnished equipment. Equipment parts warranty shall start at time of substantial completion. Contractor will provide a one (1) year warranty on all labor associated with the equipment and its' installation. Warranty shall start at date of final payment. See General Requirements for additional requirements.

1.8 GENERAL PROVISIONS

A. The general provisions of the contract, including General Conditions and Supplementary General Conditions, apply to the work specified in this Section.

1.9 DELIVERY, STORAGE AND HANDLING

A. Store and protect products under provisions of Division 1 General Requirements.
B. Deliver and store material in shipping containers with labeling in place.
C. Contractor shall store all materials shipped to the site in a protected area. If material is stored outside of the building, it must be stored off the ground a minimum of six inches set on 6 x 6 planks and/or wood pallets. All material must be completely covered with waterproof tarps or visqueen. All piping will have the ends closed to keep out dirt and other debris. No equipment will be allowed to be stored on the site unless it is sitting on wood planks and is completely protected with weatherproof covers.
D. Material and Equipment: Transport, handle, store, and protect products.
E. Protect units on site from physical damage. Store in protected are on palates and wood drainage as required to keep the equipment clean and level after delivery to the site. Covered and protect the equipment from weather, dirt and damage with tarps and framing as required.

1.10 PROJECT RECORD DOCUMENTS

A. Submit record documents under provisions of Division 1 General Requirements.

1.11 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Division 1 General Requirements.
B. Include manufacturer’s descriptive literature, operating instructions, installation instructions, maintenance and repair data and parts listings.

PART 2 – PRODUCTS

2.1 HORIZONTAL AND VERTICAL PIPE ENCLOSURE

A. Provide 14-gauge, 2-sided sheet metal pipe chase for horizontal pipe enclosure. Enclosures shall be security installation type and shall be one piece. Enclosures shall be field measured for actual enclosure lengths and shall include the following installation accessories.
   1. Provide 1" x 1" 18-gauge steel angles to mount chase vertically. Drill and secure in field with tamper proof screws, spaced as recommended by chase manufacturer.
   2. Pre-punch ¼" diameter holes in enclosure 1'-0" on center. Drill and secure chase to angle as described above.
   3. End caps at non-wall terminations.
B. Prime and paint finished enclosure installation per Architect/Owner's color selection.
C. Sheet metal pipe enclosure chase shall be as manufactured by Vulcan, type "PE", or equal.

2.2 HYDRONIC FINNED TUBE RADIATION

A. Manufacturers:
   1. Runtal.
   2. No Substitutions.
B. Thermo Touch:
   1. Radiation shall be of one-piece all-welded steel construction, consisting of active flattened hot water heating tubes welded to headers at each end, plus a front set of inactive tubes for added thermal protection, with a total depth of no more than 2-3/4”. The radiator shall include an integral heavy gauge (0.09” minimum) all-welded perforated flat top grille which covers the entire radiator from the front inactive tubes to within ¼” of the wall.
   2. Provide models to have steel corrugated fins welded to both sides of the active water tubes to increase the convective output of the unit. There shall be no less than 32 fins per foot. Fins shall start within 1” of the headers, and shall be spot-welded three times per tube.

3. Headers shall include all necessary inlet, outlet and vent connections as required. Standard connection sizes are ¾" NPT tapered thread for supply and return piping, and 1/8" for the vent connection. Internal baffling is provided where required for proper water flow.
4. Radiation shall be capable of being mounted to typical stud wall construction without additional blocking or strapping. Appropriate wall mounting brackets shall be provided with the radiation.
5. Pressure rating:
   a. Standard: Working pressure-56 PSI maximum, Test Pressure-74 PSI maximum OR
   b. Medium: Working pressure-85 PSI maximum, Test Pressure-110 PSI maximum OR
   c. High: Working pressure-128 PSI maximum, Test Pressure 184 PSI maximum
6. Radiation expansion shall not exceed 1/64" per foot of radiation at 215ºF. The installer shall provide adequate expansion compensation for each radiator.
7. Radiation shall be cleaned and phosphatized in preparation for the powder coat finish. The radiation is then finish painted with a gloss powder coat finish, for a total paint thickness of 2-3 mils (0.002" - 0.003"). The color shall be selected form the Runtal's standard colors, or optional colors shall be available at and additional cost.
8. Trim covers shall be furnished with the radiation to provide a finished installation.
9. Warranty:
   a. Radiators will have a five-year standard limited warranty.

C. Type RF:
1. The wall hung heating panel radiation shall be of one-piece all-welded steel construction, consisting of flattened water tubes welded to headers at each end. The radiator shall include an integral heavy gauge (0.09" minimum) all-welded perforated top grille (for curved radiators the grille is omitted). Radiation to have steel corrugated fins welded to the rear side of the water tubes to increase the convective output of the unit. There shall be no less than 32 fins per foot. Fins shall start within 1" of the headers, and shall be spot-welded three times per tube.
2. The radiator's headers shall include all necessary inlet, outlet and vent connections as required. Standard connection sizes are ¾" NPT tapered thread for supply and return piping, and 1/8" for the vent connection. Internal baffling is provided where required for proper water flow.
3. Radiation shall be capable of being mounted to typical stud wall construction without additional blocking or strapping. Appropriate wall mounting brackets or optional floor post mounting shall be provided with the radiation. Panel radiation expansion shall not exceed 1/64" per foot of radiation at 215ºF. The installer shall provide adequate expansion compensation for each radiator.
4. Pressure Ratings:
   a. Standard: Working pressure-56 PSI maximum, Test Pressure-74 PSI maximum OR
5. Finishes:
   a. The panel radiation shall be cleaned and phosphatized in preparation for the powder coat finish. The radiation is then finish painted with a gloss powder coat finish, for a total paint thickness of 2-3 mils (0.002" - 0.003"). The color shall be selected by Architect.
6. Warranty:
   a. All radiators are covered by a 5-Year Limited Warranty.
7. Options:
   a. Ribbed pipe cover trims, finished to match the radiators shall be provided with the radiation.

2.3 SUSPENDED UNIT HEATERS (HOT WATER)

A. Manufacturer:
1. Riitling.
2. Sterling Heating Equipment.
3. Trane Co.
4. Vulcan Radiator Corporation.

B. Coils: Seamless copper tubing, copper or SS headers, and with evenly spaced aluminum fins mechanically bonded to tubing.
C. Casing: 0.0478-inch steel with threaded pipe connections for hanger rods.
D. Finish: Factory applied baked enamel of manufacturer standard color.
E. Fan: Direct drive propeller type, statically and dynamically balanced, with fan guard; horizontal models with permanently lubricated sleeve bearings; vertical models with grease lubricated ball bearings.
F. Air Outlet: Adjustable pattern diffuser on projection models and two-way louvers on horizontal throw models.
G. Motor: Permanently lubricated sleeve bearings on horizontal models, grease lubricated ball bearings on vertical models.
H. Control: Local thermostat by BAS contractor.
I. Capacity: As scheduled, based on 65-degree F. entering air temperature, 140-degree F average water temperature.
J. Electrical Characteristics:
    1. 120 volts, single phase, 60 Hz.
    2. Refer to Section 16180.

2.4 CABINET UNIT HEATERS (HOT WATER)

A. Manufacturer:
    1. Riitling.
    2. Sterling Heating Equipment.
    3. Trane Co.
    4. Vulcan Radiator Corp.
B. Fabrication:
    1. Coils: Evenly spaced aluminum fins mechanically bonded to copper tubes and copper or SS headers, designed for 100 psi and 220 degrees F.
    2. Cabinet: 16-gauge steel with exposed corners and edges rounded easily removed panels, glass fiber insulation.
    3. Finish: Factory applied baked enamel of color as selected by Architect on visible surfaces of enclosure or cabinet.
    4. Fans: Centrifugal forward curved double width wheels, statically and dynamically balanced, direct driven.
    5. Motor: Sleeve bearings, resiliently mounted.
    6. Control: Multiple speed switch, factory wired, located in cabinet, local thermostat by BAS contractor.
    7. Field install all valves and controls.
    8. Size and Capacity: As scheduled on the Drawings.
    9. Filter: Easily removed one-inch-thick pleated throw-away type, located to filter air before coil to collect construction dust. Units submitted without pleated filters will not be accepted.
    10. Speed controller: 0 – 10-volt infinite speed controller for EC motor.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Verify that surfaces are ready to receive work and opening dimensions are as indicated on shop drawings.
B. Verify that required utilities are available, in proper location and ready for use.
C. Beginning of installation means installer accepts existing conditions.
D. Provide start-up and labor warranty.

3.2 INSTALLATION

A. Hydronic Finned Tube Radiation.
   1. Install in accordance with manufacturer's instructions.
   2. Locate baseboard radiation on outside wall and run cover continuously unless otherwise indicated. Center elements under windows. Where multiple windows occur over units, divide element into equal segments centered under each window. Install end caps where units end.
   3. Mount all piping and elements from steel supports and slide cradles.
   4. Install the following minimum pipe trim on each section of controlled radiation.
   5. Note: See typical finned tube radiation piping detail on the Drawings.
      a. Inlet Side of Element: Ball valve, strainer, union, control valve and increaser.
      b. Outlet Side of the Last Piece of Element in a Controlled Section: Reducer, union, balancing valve and ball valve and key operating manual air vent.
   6. Pitch piping and finned element up to air vent.
   7. Install all valves in a location so they can be reached through the fin tube cover access door.
   8. Building Automation Contractor shall furnish control valve. This Contractor shall install control valve. This Contractor shall install valve in piping system.
   9. Protect finish surfaces during construction.

B. Suspended Unit Heater (SUH) Hot Water:
   1. Install in accordance with manufacturer's instructions.
   2. Hang units from building structure with steel hanger rods (not from piping). Mount as high above the floor as possible to maintain greatest headroom.
   3. Install swing joints on branch piping which connects to the unit heater.
   4. Insulate all branch piping from mains to unit.
   5. Install the following minimum pipe trim on each unit. See Drawings for suspended unit heater piping details.
      a. Inlet Side of Coil: Ball valve, strainer, dirt leg, union, pipe reducer.
      b. Outlet Side of Coil: Pipe increaser, union, balancing valve, manual air vent and ball valve.
      c. Combination pipe package with valves noted above should be provided. See details for additional requirements.

C. Cabinet Unit Heaters (CUH) Hot Water:
   1. Install in accordance with manufacturer's instructions.
   2. Install swing joints on all branch piping which connects to cabinet unit heaters.
   3. Insulate branch piping from mains up to the coil connection inside the unit.
   4. Install the following minimum trim on each unit. See Drawings for cabinet unit heater piping details.
      a. Inlet Side of Coil: Ball valve, strainer, union, pipe reducer.
      b. Outlet Side of Coil: Pipe increaser, union, air vent, balancing valve, ball valve.
      c. Combination pipe package with valves noted above should be provided. See details for additional requirements.
   5. Install a construction filter during construction. Install a permanent filter after building has been accepted as substantially complete.
   6. Protect finished surfaces during construction.
   7. Replace pleated construction filters with final pleated filters at substantial completion.

3.3 CLEANING

A. Clean work under provisions of Division 1 General Requirements.
B. After construction is completed, include painting, clean exposed surfaces of units. Vacuum clean coils and inside cabinets.
C. Touch-up marred or scratched surfaces of factory finished cabinets, using finish materials furnished by manufacturer.

3.4 OPERATION AND MAINTENANCE DATA BY INSTALLING CONTRACTOR

A. At the completion of the project, the Installing Contractor shall provide furnish two (2) hard copies and two (2) electronic copies of equipment manuals, maintenance manuals and repair parts list for all equipment and systems reviewed. See General Requirements for additional requirements.

END OF SECTION

SECTION 15838

VERTICAL UNIT VENTILATORS

PART 1 – GENERAL

1.1 WORK INCLUDES

A. Field verification of unit dimensions. Contractor/manufacturer shall field verify all dimensions prior to release of units.
B. Delivery of equipment to the job site.
C. Field start-up services at the job site by the mechanical and BAS contractors.
D. Electrical Power Connection.
E. Two-year non-pro-rated parts by manufacturer and one-year labor warranty by contractor.

1.2 SCOPE

A. Furnish each unit with low leak outside air and return air dampers, hot/chilled water heating/cooling coil, freeze protection, supply fan(s), filters, end device package and other equipment/devices specified in this section and on the drawing.
B. Manufacturer shall have a minimum of ten-plus year's prior experience making similar equipment as described in this specification.

1.3 OPERATION AND MAINTENANCE

A. Submit two (2) hard copies and one (1) PDF of operation and maintenance data and manufacturer installation instructions to successful contractor for inclusion in project manual.
B. Include manufacturer's descriptive literature, operating instructions, cleaning procedures, replacement parts list and maintenance and repair data to successful contractor for inclusion in project manual.

1.4 RELATED SECTIONS

A. Section 15990 – Mechanical Systems Commissioning.

1.5 SECTION INCLUDES

A. Vertical Unit Ventilators.

1.6 REFERENCES

A. NFPA 70 - National Electrical Code.
B. IBC 2015, IMC 2015 and 2018 IECC.
C. ASHRAE 62 Demand Controlled Ventilation.

1.7 SUBMITTALS

A. Submittal Documents: Provide project specific, manufacturer's submittal data for all material and equipment provided under this section including cut sheets on all components, assembly details, dimensions, weights and loading, required clearances, and location and size of field connections.
    1. Include detailed description of all materials provided with dimensions and connections clearly indicated. This includes accessories required for complete system and wiring and/or piping diagrams required to determine suitability for this specific installation/application.
    2. Include complete performance data for all design conditions indicated on the schedules.
    3. Include complete wiring diagrams for power and control, including all control devices (factory wired) with wiring diagram and cut sheets, including but not limited to:
        a. Sensors and Freeze-stat
        b. OA/RA Damper Actuators (2-10 VDC with damper position feedback).
        c. Terminal block
        d. Transformer
        e. Fan relay
        f. Fan speed control (0-10 VDC)
B. General Conditions Contract Closeout: Follow procedures indicated in Division 1.
C. Operation and Maintenance Data: Include start up reports, start-up instructions, maintenance instructions, parts lists, controls, and accessories.

D. Product Data: Provide typical catalog of information including arrangements.
E. Shop Drawings:
   1. Indicate cross sections of cabinets, grilles, bracing and reinforcing, and typical elevations.
   2. Submit schedules of equipment and enclosures typically indicating length and number of pieces of element and enclosure, corner pieces, end caps, cap strips, access doors, pilaster covers, and comparison of specified heat required to actual heat output provided.
   3. Indicate mechanical and electrical service locations and requirements.
F. Submit under provisions of Division 1 General Requirements.
G. Provide complete control drawings for the unit ventilator manufacturer provided wiring and end devices, including:
   1. Cut sheets on the unit vent manufacturer provided controls, wiring and termination diagram.
   2. Cut sheets for unit vent manufacturer provided end devices: temperature sensors, pressure switches, current transformers, valves, damper actuators.
   3. A complete point to point schematic wiring diagram showing all control components and wiring labeled to match the delivered equipment.
H. Indicate capacity and dimensions of manufactured products and assemblies required for this project. Indicate electrical service with electrical characteristics and connection requirements, and duct connections.
I. Submit manufacturer's installation instructions. Indicate assembly, support details, connection requirements, and include start-up instructions.
J. Contractor shall review all shop drawings prior to submitting them for Architect/ Engineer's review. Contractor shall stamp each shop drawing to certify that he has reviewed it. Engineer will not check shop drawings that contractor has not stamped with his review certification.

1.8 SUBMITTALS AT PROJECT CLOSEOUT

A. Project Record Documents: Record actual locations of components and locations of access doors in radiation cabinets required for access or valuing.
B. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listings.
C. Warranty: Submit manufacturer warranty and ensure forms have been completed in Owners name and registered with manufacturer.

1.9 WARRANTY

A. Contractor to provide a two (2) year parts warranty by manufacturer and one (1) year warranty on all labor associated with the equipment and its installation. See General Requirements for additional requirements and start date.

PART 2 – PRODUCTS

2.1 MANUFACTURER

A. Change Air.
B. No substitutions.

2.2 VERTICAL UNIT VENTILATORS – HOT/CHILLED WATER – TWO PIPE

A. Description: The supplied product shall be a hot water heating and chilled water cooling configuration unit ventilator. The unit shall be floor-mounted and vertically configured to allow the supply air to be ducted from the top of the unit. All access and maintenance shall be through the front of the unit.
B. Coils: Coils shall be manufactured from 3/8" diameter copper tubing mechanically bonded onto aluminum fins with coil circuitry designed to ensure minimum airside pressure drops. The cooling coil shall be mounted in a sloped condensate pan to minimize standing water.

C. Cabinet: Suitable for standalone installation with ducted outdoor/return/supply air openings and fabricated from galvanized sheet steel. Supply air shall discharge vertically from the top of the unit via ductwork. The outdoor air will be ducted to the back of the unit and the return air will ducted to the side of the unit. All component access shall be from the front of the unit. No side access shall be required. The front of the unit shall allow access to the bottom sound attenuating inlet plenum. The door shall be hinged to allow for easy removal if required. Doors shall be secured with a key lock(s). The back of the unit shall have a duct opening for outdoor air. Field piping connections shall be located at the top of the unit. All factory installed piping shall be fully insulated with 3/8" wall closed cell type insulation. The cabinet shall be insulated with 1" closed cell insulation.

D. Finish: The cabinet shall be degreased and coated with dry powder, epoxy resin paint, baked after application. The paint finish shall be textured, easily cleanable and hard wearing to give maximum protection. Color to be as selected by the Architect from manufacture standard colors.

E. Supply/Relief Fan & Fan Motor: Supply and relief airflow shall be provided by a double inlet, forward curved, centrifugal fan with integral direct drive electrically commutated motor (ECM). The assembly shall be statically and dynamically balanced to ensure smooth running and minimum noise levels. The ECM fan motor shall be factory programmed to supply the specified airflow.

F. Filter: Each unit shall be fitted with a 1" thick pleated disposable synthetic filter, designed to meet ASHRAE standard 52-76. The filter shall be accessible from the front of the unit for easy replacement, however it shall be mounted in a position so that all return and outdoor air shall be filtered prior to being conditioned. The filters must be available from suppliers in standard sizes and each unit scheduled. Replace pleated construction filters with final pleated filters at substantial completion.

G. Economizer Dampers: Each unit shall be fitted with a spring return modulating damper that acts to mix the outdoor air with the return air. The damper shall have the capability of permitting only the outside air into the space or recycling the return air and allowing only a minimum of outside air to enter the space. Full modulation allowing any mixture of outside air and return air shall be possible. A minimum damper position setting shall also be possible to continuously maintain outside air ventilation requirements dependent on controls. The damper blade shall pivot on self-lubricating nylon bearings and modulate using an electronically controlled damper actuator. Damper actuators to be Belimo only.

H. Drain Pan: All units shall have a sloped drain pan constructed of insulated plastic or stainless steel. Drain pan shall be furnished with an anti-bacterial coating.

I. Discharge Duct Flange: The 1" factory fitted discharge duct flange shall be supplied to allow for easy installation of a discharge duct to the unit.

J. Fan Speed Control: An electronic speed control board shall be mounted internally enabling field adjustment of the supply air volume. The output of the speed fan control will be a 0 – 10 VDC signal to the ECM supply fan and the inputs shall be 24VAC signals from the control system.

K. Freeze Protection: The unit shall be fitted with two freeze protection sensors to prevent any freezing of the hot water coil assembly. When the initial sensor detects a potential freeze up condition it shall shut the outside air damper and automatically reset when the danger has passed. A second sensor will send a signal to the control systems when a freeze up condition is present and the controller shall force the hot water 2-way control valve open to the coil and prevent the supply fan from running until manually reset.

L. Disconnect Switch: The unit shall be fitted with a power disconnect switch located in the unit. Sized for the full load amperage of the unit to enable the unit to be disconnected from the power supply prior to any maintenance. In the off position, the switch can be locked out.

M. Control Panel: Located behind the front door, the control panel shall contain a 75 VA 24-volt control circuit transformer and all necessary contactors and relays to provide the necessary control. All components, and terminal blocks located in the panel shall be clearly marked for easy identification. All electrical wires shall be color coded and properly identified on a wiring diagram located inside the enclosure.

N. End Package Controls: The Unit shall be fitted with control components that can be utilized by a third-party controls contractor. These devises listed below shall be wired to a terminal strip within the control panel and clearly labeled as to the devise it serves.
   1. Electrical damper operators (OA/RA) supplied by unit manufacturer. (Belimo only). 2-10 VDC with damper position feedback.
   2. Low limit thermostat.
   3. Fan relay.
   4. Fan speed control (0-10 VDC)

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.
B. Locate all unit ventilators where indicated on the Drawings.
C. Coordinate exact location of all unit ventilators existing supply/return and outdoor air ductwork locations.
D. Protect all finished surfaces with cover during balance of construction.
E. Install all drain lines from drain pan to Janitors closets and/or as shown on drawings.
F. Install supply/return/outdoor air ductwork from each unit as indicated on contract documents, include flexible duct connection at each connection to unit.
G. After construction is completed, include painting, clean exposed surfaces of units. Vacuum clean coils and inside cabinets.
H. Touch-up marred or scratched surfaces of factory finished cabinets, using finish materials furnished by manufacturer.
I. Provide field fabricated return air plenum(s) and access panels per the contract drawings.

END OF SECTION

SECTION 15855

AIR HANDLING UNITS

PART 1 – GENERAL

1.1 WORK INCLUDES
A. Delivery of equipment to the job site.
B. Field start-up services and Owner training at the job site.
C. Electrical Power Connection.
D. One-year non-pro-rated parts and labor warranty on all units.

1.2 RELATED SECTIONS
A. Section 15990 – Mechanical Systems Commissioning.

1.3 SCOPE
A. Packaged Central Station Variable Air Volume Air Handling Unit:
   1. Hot/Chilled water-cooling coil sections.
   2. Access sections with full size doors.
   3. Filter mixing box sections.
   4. Economizer section.
   5. Supply fan section.
   6. Return/exhaust fan Section.
   7. Heat recovery wheel.
   8. Factory wired and mounted variable frequency drive and mechanical bypass.
B. Manufacturer: Company specializing in manufacturing the products specified in this section with minimum ten years documented experience.

1.4 SUBMITTALS
A. Submit two (2) copies of product data including general assembly, components, controls, safety controls and wiring diagrams.
B. Shop Drawings: Indicate capacity and dimensions of manufactured products and assemblies required for this project. Indicate electrical service with electrical characteristics and connection requirements, and duct connections.
   1. Include detailed description of all materials provided with dimensions and connections clearly indicated. This includes accessories required for complete system and wiring and/or piping diagrams required to determine suitability for this specific installation/application.
   2. Include complete performance data for all design conditions indicated on the schedules.
C. Submit manufacturer’s installation instructions. Indicate assembly, support details, connection requirements, and include start-up instructions.
D. General Conditions – Operation and Maintenance Data: Submittals for project closeout.
E. Operation and Maintenance Data: Include manufacturer’s descriptive literature, operation instructions, installation instructions, maintenance and repair data, and parts listing.

1.5 OPERATION AND MAINTENANCE
A. Submit two (2) hard copies and one (1) PDF of operation and maintenance data and manufacturer installation instructions to successful contractor for inclusion in project manual.
B. Include manufacturer's descriptive literature, operating instructions, cleaning procedures, replacement parts list and maintenance and repair data to successful contractor for inclusion in project manual.

1.6 SECTION INCLUDES
A. Air Handling Units.

1.7 REFERENCES
A. NFPA 70 - National Electrical Code.
B. IMC 2015 and IECC 2018.
C. ASHRAE 62 Demand Controlled Ventilation.
D. AFBMA 9 - Load Rating and Fatigue Life for Ball Bearings.
E. AFBMA 11 - Load Rating and Fatigue Life for Roller Bearings.

F. AMCA 99 - Standards Handbook.
G. AMCA 210 - Laboratory Methods of Testing Fans for Rating Purposes.
H. AMCA 300 - Test Code for Sound Rating Air Moving Devices.
I. ARI 410 - Forced-Circulation Air-Cooling and Air-Heating Coils.
J. ARI 430 - Standard for Central-Station Air-Handling Units.
K. NFPA 70 - National Electrical Code.
L. SMACNA - Low Pressure Duct Construction Standards.

1.8 SUBMITTALS AT PROJECT CLOSEOUT

A. Project Record Documents: Record actual locations of components and locations of access doors in radiation cabinets required for access or valuing.
B. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listings.
C. Warranty: Submit manufacturer warranty and ensure forms have been completed in Owners name and registered with manufacturer.

1.9 WARRANTY

A. Contractor to provide a one (1) year warranty on all labor associated with the equipment and its installation. See General Requirements for additional requirements and start date.

PART 2 – PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Carrier.
B. No substitutions.

2.2 GENERAL DESCRIPTION

A. Configuration: Fabricate with fan and other sections as indicated in AHU Schedule:
   1. Hot/Chilled water-cooling coil sections.
   2. Access sections with full size doors.
   3. Filter mixing box sections.
   4. Economizer section.
   5. Supply fan section.
   6. Return/exhaust fan Section.
   7. Heat recovery wheel.
   8. Factory wired and mounted variable frequency drive and mechanical bypass.
B. Performance Base: Sea level conditions.
C. Fabrication: Conform to AMCA 99 and ARI 430.

2.3 GENERAL

A. Unit shall be constructed of a complete frame with all removable panels. Removal of side panels must not affect the structural integrity of the unit.
B. The casing shall be able to withstand up to 6-inches positive or 4-inches negative static pressure
C. Stainless-steel drain pans are part of structural design.

2.4 CASING

A. Construction: Double wall insulated G90 galvanized steel. Assemble sections with closed cell foam gaskets and bolts.
   1. Outside Casing:
      a. Galvanized Steel: 16-gauge minimum.
   2. Inside Casing:
      a. Galvanized Steel: Solid, 20-gauge minimum.

B. Insulation: Double-Wall Solid - Panels shall be of two-inch double-wall construction to prevent fiberglass erosion into the air stream and to facilitate cleaning of the unit interior. Interior wall to be constructed of solid G90 galvanized steel. Insulation shall be 3.0- pound/foot2 density. The thermal resistance (R) shall be 7.69 F feet2 h/Btu.
C. Unit Base / Frame / Floor: Provide a full perimeter welded base frame manufactured with structural steel tubing and C-Channel cross support members on close centers. Unit frame shall be from 14-gauge carbon tubular steel, mig welded to form a unitized assembly for support of all internal components. Base rails shall be fitted with lifting lugs at the corner of the unit or section (if de-mounted). The base shall include a 4-inch thick insulated floor with minimum 20-gauge G-90 galvanized outer and a 12-gauge aluminum tread-plate inner surface. All floor seams shall be gasketed, caulked and sealed for an airtight floor. Where access is provided to the unit interior, floor openings shall be covered with walk on steel safety grating. Single wall floors with glued and pined insulation are not acceptable. Base frame shall be attached to the unit at the factory.
D. Walk-in Access Doors: All access doors shall be constructed with a full two-inch, insulated, double-wall of solid G90 galvanized steel.
    1. Automotive style neoprene gasketing around the full perimeter of the access doors shall be used to prevent air leakage.
    2. Door hardware shall be surface mounted to minimize penetrations in the door casing that could lead to air leakage paths.
    3. All access doors shall be hinged and removable for quick, easy access.
    4. Access doors shall be provided up and downstream of all serviceable components e.g. coils, filters, fans, etc.
    5. ALL access doors shall be minimum; 14" wide by 42" high or 85% of module height by 75% of module width, whichever is greater, up to 24" x 60".
E. Drain Pans: Construct from insulated, double-wall stainless steel, 2-way sloping IAQ drain pan to allow for proper cleaning and condensate removal.
    1. Drain pan will cover the entire coil section. Cross break and pitch to drain connection.
    2. Provide drain pans under cooling coil section.
    3. Provide drain connections on both sides of unit.
    4. Provide base rails or legs (as required) to guarantee 4" clear from bottom of drain connection to top of (6") housekeeping pad for proper trapping (10" total clear).
F. Bottom Inlet Units: Provide steel or aluminum walking grate on structural supports.

2.5 FAN MODULE

A. The vibration levels of the complete fan assembly shall be tested and excessive vibration (including that caused by fan imbalance) shall be eliminated in the factory. Fan shaft shall be properly sized and protectively coated with lubricating oil. Fan wheels shall be keyed to fan shaft to prevent slipping. Fan shafts shall be solid and designed so that fan shaft does not pass through its first critical speed as the unit comes up to its rated rpm. Fan shafts shall not exceed 75 percent of their first critical speed at any cataloged rpm. Fan modules shall be provided with a hinged access door on the drive side of the fan.
    1. FC Fan Modules – Fan shall be double-width, double-inlet, multi-blade type as produced by the unit manufacturer. Fan shall be forward curved (FC) as required for stable operation and optimum energy efficiency. Fan shall be equipped with self-aligning, antifriction bearings with an L-50 life of 200,000 hours. Fan performance shall be certified as complying with ARI 430-89.
    2. BI Fan Modules – Fan shall be double-width, double-inlet, multi-blade type as produced by the unit manufacturer. Fan shall be backward inclined (BI) as required for stable operation and optimum energy efficiency. Fan shall be equipped with self-aligning, antifriction bearings with an L-50 life of 200,000 hours. Fan performance shall be certified as complying with ARI 430-89.

3. Plug Fan Modules - Fan shall be single-width, single-inlet, multiblade type plug fan. The fan blades shall be backward inclined airfoil (AF) with minimum of 12 blades per wheel. Plug fans shall be equipped with self-aligning, antifriction pillow block bearings with an L-50 life of 200,000 hours.

B. Combination Variable Frequency Drives with Mechanical Bypass
   1. Variable Frequency Drive - Supply and return/exhaust fan for VAV and CAV systems shall be modulated by a variable frequency drive and mechanical bypass, controlling fan speed and factory mounted and wired by the air handling unit manufacturer.
   2. Acceptable Manufacturers:
      a. Johnson Controls VSD Series.
      b. ABB.
      C. No Substitutions.
   3. Combination variable frequency drives and mechanical bypass shall be factory wired in liquid tight conduit with junction boxes from VFD to motor, and mounted to unit frame. Unit must be factory balanced through the full speed range.
   4. Variable frequency drive shall be pulse width modulated with IGBT transistors and include the following:
      a. LCD Display and Keypad
      b. English Language Electrical Values, Parameters, Self Test, Faults and Diagnostics.
      c. Power, Pending Fault, and Fault Indicator Lights
      d. Form C Fault Contacts.
      e. 4-20 mA or 0-10 Speed Input Signal
      f. Adjustable ramp up/down time to full speed of 0 to 3600 seconds.
      h. Hand-Off-Auto (HOA) selector switch
      i. Current limiting NEMA Class T fuses.
      j. Separate drive/off/bypass selector switch.
      k. Auto restart after momentary power loss.
      l. Critical frequency avoidance.
      n. Voltage and FLA shall be factory-set for the exact motor used in the air handler.
   5. VFD, bypass and controls shall be provided in a NEMA 1 enclosure with manual bypass/disconnect switch independent of the VFD controls:
      a. Circuit breaker disconnect switch shall be interlocked to a through the door operating mechanism.
      b. The Bypass and drive shall be factory assembled and electrically interlocked using three (3) contactors. VFD shall be removable with by-pass control in place and remain operational.
      c. Include 115 VAC transformer, control terminal strip and Input/Output/Bypass contactors.
   6. Factory mounted controls shall be covered by the air handler manufacturer's standard one year parts and labor warranty.
   7. Provide BACNET card.

C. Fan Isolation
   1. Fan connection shall be isolated from unit casing by a flexible canvas duct.
   2. Fan and motor assemblies shall be internally isolated from unit casing with a housed 2-inch deflection spring isolator, furnished and installed by unit manufacturer.

D. Drives
   1. Fixed Pitch - Drives shall be constant speed with fixed pitch sheaves.
   2. 1.5 Service Factor - Drives shall be selected at 1.5 service factor.

E. High Efficiency Motors
   1. Motor shall be mounted integral to an isolated fan assembly furnished by the unit manufacturer. Motor shall be mounted inside the unit casing on a slide base to permit adjustment of drive belt tension.
   2. Open Drip-Proof - Motor shall be a T-frame, squirrel cage, open drip-proof with size, type and electrical characteristics as shown on equipment schedule. Motor efficiency equivalent to Century E+3.

F. Fan Module Options
   1. Grease Lines - Grease lines of both bearings shall be extended to the fan support bracket on the drive side.

2.6 WATER COIL MODULES (HEAT OR COOL)

A. Casing: Provide hinged access doors to both sides of coils (may require access section). Enclose coils with headers and return bends fully contained within casing.
B. Drain Pans: Stainless steel, double pitched as in 2.3.G above. Provide intermediate drain channels and down spouts for cooling coil banks more than one coil high, to drain condensate to the main drain pans without flooding the lower coils or passing condensate through the air stream of the lower coil.
C. Air Coils: Certify capacities, pressure drops, and selection procedures in accordance with ARI 410. Refer to ASU Schedule for minimum requirements.
D. Fabrication:
   1. Tubes: 5/8-inch OD, 0.025" thick wall, seamless copper expanded into fins, brazed joints.
   2. Fins: Aluminum with 0.008” thick fins shall have collars drawn, belled and firmly bonded to tubes by mechanical expansion of the tubes. Soldering or tinning shall not be used in the bonding process.
   3. Cooling coils shall have stainless steel coil casings.
E. Water Heating/Cooling Coils:
   1. Headers: Stainless Steel, seamless copper tube, or prime coated steel pipe with brazed joints.
   2. Configuration: Drainable, with threaded plugs for drain and vent; threaded plugs in return bends and in headers opposite each tube.
   3. Supply and return headers clearly labeled on outside of unit.
   4. Casing: Die formed channel frame on all sides of 304 stainless steel.
   5. Burst test to 300 psig and proof test to 200 psig under water in factory.
   6. Safe off around coils for no air bypass.
   7. Coils shall have stainless steel coil casing.

2.7 FILTER SECTION

A. Filter Box: Section with filter guides, access doors from both sides, for side and face loading with gaskets and blank-off plates.
B. Filter Media: One set of 2" pleated 30% filters shipped in unit. Three (3) spare sets per AHU for Owner stock to be shipped at time of start-up.
C. Filter rack shall be angled or flat (see schedule). Maximum face velocities shall not be exceeded.
D. Filter Gauges: 3½”-inch diameter diaphragm actuated dial in metal case, with static pressure tips and mounting hardware, factory installed.

2.8 DAMPERS

A. Mixing Boxes: Section with factory mounted outside, exhaust and return air dampers, equal to Ruskin Model CD-60.
   1. Galvanized steel with vinyl bulb edging and edge seals in galvanized frame.
   2. Galvanized steel axles in self-lubricating nylon or brass bearings.
   3. Opposed blade arrangement.
B. Damper Leakage: Maximum 1 percent of nominal air flow at 1" wg differential pressure when sized for 1500 fpm face velocity.
C. Actuators are to be field provided and installed by others or factory installed Belimo.

2.9 ACCESS MODULES

A. Additional dedicated access sections shall be provided such that there is a full height access door on both sides of all coil, filter and fan modules.
B. Access section shall have full height hinged access door as specified above.

2.10 TOTAL ENERGY RECOVERY WHEEL SECTION

A. Total energy recovery wheels shall be provided as indicated on the schedule and drawings. Wheels shall be integral parts of the AHUs and shall be sized per the ventilation requirement of the units. Additional outside air units, or other field assembled and ducted energy recovery devices, are not acceptable. Mixed air units with economizing shall be constructed with internal bypass dampers such that the pressure drop across the wheel does not increase during economizing. External bypass and multiple duct connections are not acceptable.

B. The air handling unit shall be certified by AHRI to contain a rotary energy recovery wheel certified to ANSI/AHRI Standard 1060 and bears the AHRI 1060 label. The air handling unit and wheel must be AHRI 1060-certified as a package. Proof of compliance shall be that the air handling unit brand name and specific wheel being used be listed on the AHRI website within the Directory of Certified Product Performance for Commercial Air-to-Air Energy Recovery Ventilators under the Packaged Program Type. Verification of performance for non-AHRI 1060 certified AHU packages shall be completed by witness test for the owner/owner's representative and specifying engineer at the jobsite. Installing contractor shall be responsible for all expenses of verification testing, including test set-up, room/board for owner/owner's representative and engineer, travel to and from the jobsite, as well as modification costs associated to achieving specified performance.

C. Performance characteristics of the energy wheel shall be provided as defined by AHRI 1060 definitions. The energy wheel shall be a total energy wheel, with the sensible and latent effectiveness reported and within 5% of each other. The calculated total net effectiveness of the recovery wheel shall not be less than 70% when the specified ventilation flow rate equals the exhaust flow rate. The energy wheel's EATR shall be less than the value indicated in the schedule and drawings. Wheel face velocity and pressure drop shall not exceed performance as defined on schedule. The energy recovery cassette shall be an Underwriters Laboratories (UL) Recognized Component certified for mechanical, electrical, and fire safety in accordance with UL Standard 1812.

D. The energy recovery component shall incorporate a rotary wheel in an insulated cassette frame complete with seals, drive motor and drive belts. The total energy recovery wheel shall incorporate a desiccant without the use of binders or adhesives, which may plug the desiccant aperture. The adsorbent shall not be applied as a glued-on surface coating and not susceptible to erosion, abrasion, or delamination. Coated segments shall be washable using standard detergent or alkaline-based coil cleaners. The adsorbent shall be selected for its high affinity for water vapor and shall not dissolve or deliquesce in the presence of water or high humidity. The rim shall be continuous rolled stainless steel to form an even concentric circle to prevent leakage around the rim and to minimize wear of components. All diameter and perimeter seals shall be provided as part of the cassette assembly. Perimeter seals shall be self-adjusting; diameter seals shall be adjustable. Seals shall be factory set.

E. Wheel drive motor shall be provided mounted in the cassette frame. Wheel drive motor shall be thermally protected and UL Component Recognized. Drive belts shall not require belt tensioners. On units that require drive belt tensioners for the wheel belt/motor assembly, the unit manufacturer shall provide at no additional charge to the customer a visual inspection every four months, and adjustment if necessary, of the recommended belt tension during the unit warranty period. Wheel motors shall be of the voltage, phase, frequency, and Hp indicated on the schedule and drawings.

F. Wheel bearings shall be permanently sealed and lubricated and have a minimum L-10 life of 400,000 hours.

G. Access doors shall be provided for the removal of wheel segments. Doors shall be located on all air entering and air leaving sides of wheel to allow access to the entire upstream and downstream face of each wheel. Adequate space and access shall be provided for energy wheel motor, bearing and belt removal. Access doors shall be constructed as stated above.

H. Energy recovery wheels shall be designed with variable effectiveness control, to vary the wheel's recovery capacity. Variable effective control shall be done by an internal bypass damper provided by the AHU Manufacturer. The wheel's variable effectiveness control shall have the ability to modulate the total energy recovery ability down to at least 40% of the initial recovery capacity. Variable frequency speed control is not an acceptable method for controlling variable effectiveness.
I. Frost prevention shall be achieved by outside air bypass, return air preheat, or outside air preheat, depending upon design conditions. Frost set point temperatures based on the scheduled design air conditions shall be provided by the AHU Manufacturer. Variable frequency speed control is not an acceptable method of frost control. Winter design supply and exhaust air conditions leaving the energy wheel shall be provided by the AHU Manufacturer and shall include any de-rate in performance due to frost prevention measures.
J. Control of energy wheels shall be incorporated and an integral part of the AHU control systems and shall be as described under the AHU control specifications. Secondary independent wheel controllers are not acceptable.

2.11 REQUIREMENTS BY INSTALLING CONTRACTOR

A. Contractor shall furnish two (2) hard copies and two (2) electronic copies of equipment manuals, maintenance manuals and repair parts list for all equipment and systems reviewed. See General Requirements for additional requirements.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.
B. Install in conformance with ARI 435.
C. Units will have internal vibration isolators.
D. Install air handling unit:
   1. 4" floor mounted concrete base.
E. Support coil sections independent of piping on steel channel or double angle frames and secure to casings. Provide frames for maximum three coil sections. Arrange supports to avoid piercing drain pans. Provide air tight seal between coil and duct or casing.
F. Protect coils to prevent damage to fins and flange. Comb out bent fins.
G. Install coils level. Install cleanable tube coils with 1:50 pitch.
H. Make connections to coils with unions and/or flanges.
I. On water coils, provide shut-off valve on supply line and flow control and shut-off valve on return line. Locate water supply at bottom of supply header and return water connection at top. Provide manual air vents at high points complete with stop valve. Ensure water coils are drainable and provide drain connection at low points.
J. On each air handling unit install one hydronic indication unit (Flow Conditioning Corp.) and connect to the inlet and outlet of each heating and cooling coil.
K. Provide drain pan connection of all units with cooling coils. Pipe drain pans individually to floor drain. Provide water seal trap on air supply units.
L. Install a 9-inch scale stem thermometer on the inlet and outlet of all air handling unit heating and cooling coils.
M. All air handling units are furnished with one set of filters. The mechanical contractor shall furnish and install one set of filters during construction and just prior to occupancy, shall remove the construction filters, dispose of them and install all new filters per Section 15885 – Air Cleaning Devices.
N. Provide sheaves, belts, pulleys, etc. required for final air balance.

END OF SECTION

SECTION 15870

POWER VENTILATORS

PART 1 – GENERAL

1.1 WORK INCLUDED
A. Power roof exhaust fans.
B. Cabinet exhaust fans.
C. Inline exhaust fans.

1.2 RELATED WORK
A. Section 15140 - Supports and Anchors.
B. Section 15890 - Ductwork.
C. Section 15910 - Ductwork Accessories.
D. Section 15990 – Mechanical Systems Commissioning.

1.3 REFERENCES
A. AMCA 99 - Standards Handbook.
B. AMCA 210 - Laboratory Methods of Testing Fans for Rating Purposes.
C. AMCA 300 - Test Code for Sound Rating Air Moving Devices.
D. NFPA 70 - National Electrical Code.

1.4 SUBMITTALS
A. Submit under provisions of Division 1 General Requirements.
B. Product Data: Provide data on fans and accessories including fan curves with specified operating point clearly plotted, sound power levels at rated capacity and electrical characteristics and connection requirements.
C. Manufacturer's installation instruction.
D. Contractor shall review all shop drawings prior to submitting them for Architect/Engineer's review. Contractor shall stamp each shop drawing to certify that he has reviewed it. Engineer will not check any shop drawings that Contractor has not stamped with his review certification.

1.5 OPERATION AND MAINTENANCE DATA
A. Maintenance Data: Include instructions for lubrication, motor and drive replacement, spare parts list and wiring diagrams under provisions of Division 1 Sections.

1.6 DELIVERY, STORAGE AND HANDLING
A. Deliver, store, protect and handle products to site under provisions of Division 1 General Requirements.
B. Contractor shall store all materials shipped to the site in a protected area. If material is stored outside of the building it must be stored off the ground a minimum of 6-inches set on 6 x 6 planks and/or wood pallets. All material must be completely covered with waterproof tarps or visqueen. All duct openings will have the ends closed to keep out dirt and other debris. No equipment will be allowed to be stored on the site unless it is sitting on wood planks and completely protected with weatherproof covers.

1.7 WARRANTY
A. Contractor shall provide a one (1) year manufacturer’s warranty on parts on furnished equipment. Equipment parts warranty shall start at time of substantial completion. Contractor will provide a one (1) year warranty on all labor associated with the equipment and its’ installation. Warranty shall start at date of final payment. See General Requirements for additional requirements.

PART 2 – PRODUCTS

2.1 POWER ROOF EXHAUST FANS AND CURBS

A. Acceptable Manufacturers:
   1. Acme.
   2. Carnes.
   3. Cook.
   4. Greenheck.

2.2 SPUN ALUMINUM, ROOF MOUNTED DIRECT OR BELT DRIVE, DOWNBLAST CENTRIFUGAL EXHAUST VENTILATOR.

A. Certifications: Fan shall be manufactured at an ISO 9001 certified facility. Fan shall be listed by Underwriters Laboratories (UL 705) and UL listed for Canada (cUL 705). Fan shall bear the AMCA certified ratings seal for sound and air performance.
B. The fan shall be of bolted and welded construction utilizing corrosion resistant fasteners. The spun aluminum structural components shall be constructed of minimum 16-gauge marine alloy aluminum, bolted to a rigid aluminum support structure. The aluminum base shall have continuously welded curb cap corners for maximum leak protection. The discharge baffle shall have stainless steel quick release latches to provide access into the motor compartment without the use of tools. An integral conduit chase shall be provided through the curb cap and into the motor compartment to facilitate wiring connections. The motor, bearings and drives shall be mounted on a minimum 14-gauge steel power assembly, isolated from the unit structure with rubber vibration isolators. These components shall be enclosed in a weather-tight compartment, separated from the exhaust airstream. Lifting lugs shall be provided to help prevent damage from improper lifting. Unit shall bear an engraved aluminum nameplate. Nameplate shall indicate design CFM, static pressure, and maximum fan RPM. Unit shall be shipped in ISTA certified transit tested packaging.
C. Wheel: Wheel shall be centrifugal backward inclined, constructed of 100 percent aluminum, including a precision machined cast aluminum hub. Wheel inlet shall overlap an aerodynamic aluminum inlet cone to provide maximum performance and efficiency. Wheel shall be balanced in accordance with AMCA Standard 204-96, Balance Quality and Vibration Levels for Fans.
D. Motor: Motor shall be heavy duty type with permanently lubricated sealed ball bearings and furnished at the specified voltage, phase and enclosure.
E. Speed controller: 0 – 10 volt infinite speed controller for EC motor.
F. Bearings: Bearings shall be designed and individually tested specifically for use in air handling applications. Construction shall be heavy duty re-greaseable ball type in a cast iron pillow block housing selected for a minimum L50 life in excess of 200,000 hours at maximum catalogued operating speed.
G. Belts & Drives: Belts shall be oil and heat resistant, non-static type. Drives shall be precision machined cast iron type, keyed and securely attached to the wheel and motor shafts. Drives shall be sized for 150 percent of the installed motor horsepower. The variable pitch motor drive must be factory set to the specified fan RPM. All belt drive fans to be provided with automatic belt tensioner.
H. Roof Curbs: 18-inch high stainless steel with continuously welded seams, one-inch insulation and curb bottom and factory installed door nailer strip. Curb shall be fabricated to accommodate roof pitch so fan is mounted on a horizontal level plain. Provide interior sound baffle for units where scheduled.
I. Disconnect Switch: Factory wired, non-fusible, in housing for thermal overload protected motor.
J. Inlet Damper: Motorized low leak backdraft as specified in Section 17100 Direct Digital Controls.

2.3 SPUN ALUMINUM, ROOF MOUNTED, BELT DRIVEN, UPBLAST CENTRIFUGAL EXHAUST VENTILATOR

A. Certifications: Fan shall be manufactured at an ISO 9001 certified facility. Fan shall be listed by Underwriters Laboratories (UL 705) and UL listed for Canada (cUL 705). Fan shall bear the AMCA certified ratings seal for sound and air performance.

B. Construction: The fan shall be of bolted and welded construction utilizing corrosion resistant fasteners. The spun aluminum structural components shall be constructed of minimum 16-gauge marine alloy aluminum, bolted to a rigid aluminum support structure. The aluminum base shall have a one-piece inlet spinning and continuously welded curb cap corners for maximum leak protection. A two-piece top cap shall have stainless steel quick release latches to provide access into the motor compartment without the use of tools. An integral conduit chase shall be provided into the motor compartment to facilitate wiring connections. The motor, bearings and drives shall be mounted on a minimum 14-gauge steel power assembly, isolated from the unit structure with rubber vibration isolators. These components shall be enclosed in a weather-tight compartment, separated from the exhaust airstream. Lifting lugs shall be provided to help prevent damage from improper lifting. Unit shall bear an engraved aluminum nameplate. Nameplate shall indicate design CFM, static pressure, and maximum fan RPM. Unit shall be shipped in ISTA certified transit tested packaging.

C. Wheel: Wheel shall be centrifugal backward inclined, constructed of 100 percent aluminum, including a precision machined cast aluminum hub. Wheel inlet shall overlap an aerodynamic aluminum inlet cone to provide maximum performance and efficiency. Wheel shall be balanced in accordance with AMCA Standard 204-96, Balance Quality and Vibration Levels for Fans.

D. Motor: Motor shall be heavy duty type with permanently lubricated sealed ball bearings and furnished at the specified voltage, phase and enclosure.

E. Speed controller: 0 – 10 volt infinite speed controller for EC motor.

F. Bearings: Bearings shall be designed and individually tested specifically for use in air handling applications. Construction shall be heavy duty re-greaseable ball type in a cast iron pillow block housing selected for a minimum L50 life in excess of 200,000 hours at maximum catalogued operating speed.

G. Belts & Drives: Belts shall be oil and heat resistant, non-static type. Drives shall be precision machined cast iron type, keyed and securely attached to the wheel and motor shafts. Drives shall be sized for 150 percent of the installed motor horsepower. The variable pitch motor drive must be factory set to the specified fan RPM.

H. Roof Curbs: 18-inch high stainless steel with continuously welded seams, one-inch insulation and curb bottom and factory installed door nailer strip. Curb shall be fabricated to accommodate roof pitch so fan is mounted on a horizontal level plain. Provide interior sound baffle for units where scheduled.

I. Disconnect Switch: Factory wired, non-fusible, in housing for thermal overload protected motor.

J. Inlet Damper: Motorized low leak backdraft as specified in Section 17100 Direct Digital Controls.

2.4 CABINET EXHAUST FANS

A. Centrifugal Fan Unit: Direct driven, or belt as indicated on schedules, with galvanized steel housing lined with ½-inch acoustic insulation, resilient mounted motor, gravity damper as indicated on schedules.

B. Electrical Characteristics:
   1. Electrical Characteristics:
      a. See Schedules.
      b. Refer to Division 26.
   2. Motor: - ODP ball bearing motors.
   3. Speed controller: 0 – 10 volt infinite speed controller for EC motor.

4. Wiring Terminations: Provide terminal lugs to match branch circuit conductor quantities, sizes and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70.
5. Disconnect Switch: Factory wired, non-fusible, in housing for thermal overload protected motor.

2.5 INLINE EXHAUST FANS

A. Acceptable Manufacturers:
   1. Cook.
   2. Greenheck.
   3. Carnes.
B. Product Requirements:
   1. Performance Ratings: Conform to AMCA 210 and bear the AMCA Certified Rating Seal.
   2. Sound Ratings: AMCA 301, tested to AMCA 300 and bear AMCA Certified Sound Rating Seal.
   3. Fabrication: Conform to AMCA 99.
   4. UL Compliance: UL listed and labeled, designed, manufactured and tested in accordance with UL 705.
C. Fan Unit: V-belt or direct driven as indicated, galvanized steel framework and panels with grease tray housing; resilient mounted motor; fan wheel shall be aluminum, non-overloading, backward inclined, spark resistant centrifugal type. Wheels shall be dynamically balanced. Fan housing shall be acoustically lined.
D. Units shall be equipped with three removable access panels. Motors shall be mounted out of the main airstream and positively cooled by drawing air through the motor compartment. Units shall be equipped with an electrical disconnect switch prewired to a junction box on the exterior. Motors shall be easily accessible for service.
E. Backwardly inclined, robotically welded wheels shall be spark resistant, non-overloading and dynamically balanced to ISO 1940 standards, ANSI S2.19, level G6.3. Motors shall be heavy-duty ball bearing type and mounted out of the air stream. Fans shall include adjustable motor pulleys to provide a minimum life (L50) of 200,000 hours.
F. The following accessories shall be provided by the fan manufacturer: UL safety disconnect switch; wiring between motor and disconnect switch; electrical motorized dampers; inlet and outlet guards; motors, vibration isolators and belt guards.
G. Electrical Characteristics and Components:
   1. Electrical Characteristics:
      a. See Schedules.
   2. Wiring Terminations: Provide terminal lugs to match branch circuit conductor quantities, sizes and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70.
   3. Disconnect Switch: Factory wired, non-fusible, in housing for thermal overload protected motor.
   4. Motor: Inverter duty high efficiency type.
   5. Speed controller: 0 – 10 volt infinite speed controller for EC motor.
H. Sheaves: Browning cast iron or steel, dynamically balanced, bored to fit shafts and keyed; variable and adjustable pitch motor sheaves selected so required RPM is obtained with sheaves set at mid-position; fan shaft with self-aligning pre-lubricated ball bearings.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.
B. Secure roof exhaust fans with stainless steel lag screws to roof curb.
C. Extend ducts to roof exhaust fans into roof curb. Counter flash duct to roof opening.
D. Provide curb adaptor to match existing curbs; Field verify.
E. Provide sheaves, belts, pulleys, etc. required for final air balance.

F. Do not operate fans for any purpose until ductwork is clean, bearings lubricated and fan has been test-run under observation.
G. Install flexible connections specified, between fan inlet and ductwork. (Not applicable for roof mounted fans). Ensure metal bands of connectors are parallel with minimum one-inch flex between ductwork and fan while running.

3.2 OPERATION AND MAINTENANCE DATA BY INSTALLING CONTRACTOR

A. At the completion of the project, the Installing Contractor shall provide furnish two (2) hard copies and two (2) electronic copies of equipment manuals, maintenance manuals and repair parts list for all equipment and systems reviewed. See General Requirements for additional requirements.

END OF SECTION

SECTION 15885

AIR CLEANING DEVICES

PART 1 – GENERAL

1.1 SECTION INCLUDES
A. Disposable panel filters.
B. Filter frames.
C. Filter gages.

1.2 RELATED SECTIONS
A. Section 15836 – Terminal Heat Transfer Units.
B. Section 15838 – Vertical Unit Ventilators.
C. Section 15855 – Air Handling Units.

1.3 REFERENCES
A. ARI 850 - Commercial and Industrial Air Filter Equipment.
B. ASHRAE 52 - Method of Testing Air Cleaning Devices Used in General Ventilation for Removing Particulate Matter.
C. UL 900 - Test Performance of Air Filter Units.

1.4 PERFORMANCE TOLERANCES
A. Conform to ARI 850 Section 7.4.
B. Dust Spot Efficiency: Plus or minus 5 percent.

1.5 SUBMITTALS
A. Submit under provisions of the general conditions and general requirements of the contract.
B. Shop Drawings: Indicate filter assembly and filter frames, dimensions, motor locations, and electrical characteristics and connection requirements.
C. Product Data: Provide data on filter media, filter performance data, filter assembly and filter frames, dimensions, motor locations and electrical characteristics and connection requirements.
D. Manufacturer's Installation Instructions: Indicate assembly and change out procedures.

1.6 OPERATION AND MAINTENANCE DATA
A. Submit under provisions of the general conditions and general requirements of the contract.
B. Operation and Maintenance Data: Include instructions for operation, changing, and periodic cleaning.

1.7 EXTRA MATERIALS
A. Panel Filters:
   1. Provide one set of construction filters
   2. Replace construction filters with final pleated filters at substantial completion.

PART 2 – PRODUCTS

2.1 MANUFACTURERS
A. Panel Filters:
   1. American Air Filter.
   2. Tri-Dem.
   3. Farr.
   4. Cambridge
   5. No Substitutions

2.2 DISPOSABLE PANEL FILTERS

A. Media: UL 900 Class 2, factory sprayed with flameproof, non-drip, non-volatile adhesive, 30% efficient.
   1. Nominal Size: 12 x 24 inches or 24 x 24 inches.
   2. Thickness: 2-inch.
   3. MERV 8.
   4. Pleated.
B. Performance Rating:
   1. Face Velocity: 500 FPM.
   2. Initial Resistance: 0.15-inch WG.
   3. Recommended Final Resistance: 0.50 inches WG.
C. Casing: Cardboard frame with perforated metal retainer.

2.3 FILTER FRAMES AND HOUSINGS

A. General: Fabricate filter frames and supporting structures of 16 gage galvanized steel or extruded aluminum T section construction with necessary gasketing between frames and walls.

2.4 FILTER GAGES

A. Direct Reading Dial: 3½-inch diameter magnahelic dial in metal case, vent valves, black figures on white background, front recalibration adjustment, range 0 – 3.0-inch WG, 3 percent of full scale accuracy.
B. Accessories: Static pressure tips with integral compression fittings, ¼-inch aluminum tubing, 2-way or 3-way vent valves.

PART 3 – EXECUTION

3.1 FIELD INSTALLATION

A. Install air-cleaning devices in accordance with manufacturer's instructions.
B. Pleated Filters Only: Install filter gage static pressure tips upstream and downstream of filters. Mount filter gages on outside of filter housing or filter plenum, in accessible position. Adjust and level.
C. Do not operate fan system(s) until permanent filters are in place. Pleated Filters Only: Replace temporary filters used during construction and testing and replace with clean set. Provide Owner with attic stock.
D. Provide filter gages on filter banks, installed with separate static pressure tips upstream and downstream of filters.
E. All equipment being installed under this contract that utilizes air filter shall have new filter of this type furnished and installed at start-up.

END OF SECTION

SECTION 15890

DUCTWORK

PART 1 – GENERAL

1.1 WORK INCLUDED
A. Insulated flexible ductwork.
B. Low pressure (rectangular) ductwork.
C. Low pressure (round) ductwork.
D. Kitchen hood ductwork.
E. Installation of all dampers in ductwork.
F. Coordination of building automation system installation.
G. Installation of BAS components.

1.2 RELATED SECTIONS
A. Section 15140 - Supports and Anchors: Sleeves.
B. Section 15190 – Mechanical Identification
C. Section 15290 - Duct Insulation.
D. Section 15910 - Ductwork Accessories.
E. Section 15940 - Air Inlets and Outlets.
F. Division 17 - Building Automation System.

1.3 REFERENCES
A. ASTM A 36 - Structural Steel.
B. ASTM A 90 - Weight of Coating on Zinc Coated (Galvanized) Iron or Steel Articles.
C. ASTM A 366 - Steel, Sheet, Carbon, Cold Rolled, Commercial Quality.
D. ASTM A 525 - General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot Dip Process.
E. ASTM A 527 - Steel Sheet, Zinc Coated (Galvanized) by Hot Dip Process, Lock Forming Quality.
F. NFPA 90A - Installation of Air Conditioning and Ventilating Systems.
G. SMACNA - HVAC Air Duct Leakage Test Manual.
H. SMACNA - HVAC Duct Construction Standards - Metal and Flexible.
I. UL 181 - Factory Made Air Ducts and Connectors.

1.4 PERFORMANCE REQUIREMENTS
A. No variation of duct configuration or sizes permitted except by written permission. Size round ducts installed in place of rectangular ducts in accordance with ASHRAE table of equivalent rectangular and round ducts.

1.5 REGULATORY REQUIREMENTS
A. Construct ductwork to N.F.P.A. 90A standards.
B. Conform to 2015 International Mechanical Code and 2018 International Energy Conservation Code.

1.6 SUBMITTALS
A. Submit under provisions of Division 1 General Requirements.
B. Shop Drawings: Submit one-quarter inch shop drawing layouts of all ductwork systems prior to fabrication. Drawings are to be coordinated with other trades.
C. Test Reports: Indicate pressure tests performed. Include date, section tested, test pressure, and leakage rate, following SMACNA HVAC Air Duct Leakage Test Manual.

1.7 PROJECT RECORD DOCUMENTS
A. Submit under provisions of Division 1 General Requirements.
B. Record actual locations of ducts and duct fittings. Record changes in fitting location and type. Show additional fittings used.

1.8 QUALITY ASSURANCE

A. Perform Work in accordance with SMACNA - HVAC Duct Construction Standards - Metal and Flexible.
B. Maintain one copy of document on site.

1.9 REGULATORY REQUIREMENTS

A. Construct ductwork to NFPA 90A standards.

1.10 ENVIRONMENTAL REQUIREMENTS

A. Do not install duct sealants when temperatures are less than those recommended by sealant manufacturers.
B. Maintain temperatures during and after installation of duct sealants.

PART 2 – PRODUCTS

2.1 MATERIALS

A. General: Non-combustible or conforming to requirements for Class 1 air duct materials or UL 181.
B. All exposed ductwork that is to be painted shall be paint grip galvanized steel ductwork. ASTM A527 galvanized steel sheet. Lock forming quality G90 zinc coating in conformance with ASTM A90.
C. Steel Ducts: ASTM A525 or ASTM A527 galvanized steel sheet, lock-forming quality, having zinc coating of 1.25 oz. per sq. ft. for each side in conformance with ASTM A90.
D. Fasteners: Rivets, bolts, duct mate (TM) or sheet metal screws.
E. Sealant: Non-hardening, water resistant, fire resistive, compatible with mating materials; liquid used alone or with tape or heavy mastic.
F. Hanger Rod: Steel, galvanized; threaded both ends, threaded one end or continuously threaded.

2.2 FLEXIBLE DUCTWORK

A. Acceptable Manufacturers:
    1. Thermaflex - Flexible Technologies.
    2. Flex-Master.
    3. Wiremold.
    4. Technaflax.
    5. No substitutions.
B. Product:
    1. Flexible air ducts for connections between branch low pressure ductwork and diffusers, registers and grilles.
    2. Ductwork shall be Thermaflex Type M-KE air duct listed by Underwriter's Laboratories Standard 181 as a Class 1 flexible air duct and complying NFPA Standards 90A and 90B. Duct shall be factory made and composed of a CPE liner permanently bonded to a coated spring wire helix and supporting a fiberglass insulating blanket. Low permeability outer vapor barrier of fiberglass reinforced film laminate shall complete the composite.
        a. Maximum velocity - 4000 FPM.
        b. Maximum positive pressure through 12-inch diameter - 10 inches.
        c. Maximum positive pressure over 12-inch diameter - 4 inches.
        d. Maximum negative pressure through 12 inches - 1 inch.
        e. Thermal conductance - 0.23 BTU/Hr./sq. ft. at 75 degrees F.
        f. Maximum flamespread 25; maximum smoke developed 50.
    3. Install all flexible ducts to grilles, diffusers, registers and branch ducts with galvanized steel strap, cadmium plated and fastened with a slotted bolt.

2.3 LOW PRESSURE (RECTANGULAR) DUCTWORK

A. Fabricate and support in accordance with SMACNA Low Pressure Duct Construction Standards and ASHRAE handbooks, except as indicated. Provide duct material, gauges, reinforcing and sealing for operating pressure indicated.
B. Size round ducts installed in place of rectangular ducts in accordance with ASHRAE table of equivalent rectangular and round ducts. No variation of duct configuration or sizes permitted except by written permission.
C. Construct T's, bends and elbows with radius of not less than 1-1/2 times width of duct on centerline. Where not possible and where rectangular elbows are used, provide air foil turning vanes. Where acoustical lining is indicated, provide turning vanes of perforated metal with glass fiber insulation.
D. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible. Divergence upstream of equipment shall not exceed 30 degrees; convergence downstream shall not exceed 45 degrees.
E. Provide easements where low pressure ductwork conflicts with piping and structure. Where easements exceed 10 percent duct area, split into two ducts maintaining original duct area.
F. Use crimp joints with or without bead for joining round ducts sizes 8 inch and smaller with crimp in direction of air flow.
G. Use double nuts and lock washers on threaded rod supports.
H. Seal all joints and fittings throughout the low-pressure duct system (supply side) with SMACNA approved sealants. Sealants to have a service temperature range of -30 degrees F. to +175 degrees F.

2.4 LOW PRESSURE (ROUND) DUCTWORK

A. Duct rated for 2" pressure class.
B. Adjustable elbows for all changes of direction.
C. All fittings shall be screwed to duct.

2.5 KITCHEN HOOD DUCTWORK

A. Fabricate in accordance with SMACNA HVAC Duct Construction Standards – Metal and Flexible.
B. Construct of 18-gauge stainless steel, using continuous external welded joints.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.
B. Install and seal ducts in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible. 2015 International Energy Conservation Code.
C. Duct Sizes are inside clear dimensions for lined ducts, maintain sizes inside lining.
D. Provide openings in ductwork where required to accommodate controllers. Provide pitot tube openings where required for testing of systems, complete with metal can with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.
E. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
F. Use crimp joints with or without bead for joining round duct sizes 8 inch and smaller with crimp in direction of air flow.
G. Use double nuts and lock washers on threaded rod supports.
H. During construction provide temporary closures of metal or taped polyethylene on open ductwork to prevent construction dust from entering ductwork system.
I. Connect diffusers to low pressure ducts with 3 feet maximum length of flexible duct held in place with strap or clamp.

J. Connect flexible ducts to metal ducts with adhesive plus draw bands. Flexible duct allowed for final connection to diffuser only (3'-0" max. length).
K. Seal all joints in ductwork with United duct sealer and per the International Energy Conservation Code.
L. Provide residue traps in kitchen hood exhaust ducts at base of vertical risers with provisions for clean out. Use stainless steel for ductwork exposed to view and stainless steel or carbon steel for ducts where concealed.
M. Use UL-181A or 181B tapes and mastics on joints, seams and connections per SMACNA HVAC Duct Construction Standards and seal all ductwork per International Energy Conservation Code.
N. Connect ducts to fans and other air distribution equipment with mechanical fasteners, seals, mastics or gaskets.

3.2 INSTALLATION OF DIVISION 17 PRODUCTS

A. Install gauges, temperature and pressure sensors and other instrumentation in the locations directed by the BAS contractor.
B. Failure of this contractor to adequately coordinate his work with the BAS contractor shall not be justification for any request for additional payment.
C. This contractor shall include the cost of coordinating and installing related BAS components in his bid.
D. Install duct smoke detectors provided by electrical contractor.

3.3 SCHEDULES

A. DUCTWORK MATERIAL AND PRESSURE CLASS SCHEDULE

Air System	Material	Material Pressure
Low Pressure Supply (Heating and Cooling Systems)	Steel	4"
Return and Relief	Steel	4" (Negative)
General Exhaust	Steel	2" (Negative)
Outside Air	Steel	4"
Combustion Air	Stainless Steel	4"
Kitchen Hood Exhaust	Stainless Steel	4"

END OF SECTION

SECTION 15910

DUCTWORK ACCESSORIES

PART 1 – GENERAL

1.1 WORK INCLUDED
A. Air turning devices/extractors.
B. Duct access doors.
C. Duct test holes.
D. Fire dampers.
E. Flexible duct connections.
F. Volume control dampers.

1.2 RELATED SECTIONS
A. Section 15242 - Vibration Isolation.
B. Section 15790 - Air Coils.
C. Section 15870 - Power Ventilators.
D. Section 15890 - Ductwork.
E. Division 17 - Building Automation System.

1.3 REFERENCES
A. NFPA 90A - Installation of Air Conditioning and Ventilating Systems.
B. NFPA 70 - National Electrical Code.
C. SMACNA - HVAC Duct Construction Standards - Metal and Flexible.
D. UL 33 - Heat Responsive Links for Fire Protection Service.
E. UL 555 - Fire Dampers and Ceiling Dampers.

1.4 SUBMITTALS
A. Submit under provisions of Division 1 General Requirements.

1.5 PROJECT RECORD DOCUMENTS
A. Submit under provisions of Division 1 General Requirements.

1.6 REGULATORY REQUIREMENTS
A. Products Requiring Electrical Connection: Listed and classified by Underwriters' Laboratories Inc., as suitable for the purpose specified and indicated.

1.7 DELIVERY, STORAGE, AND HANDLING
A. Deliver, store, protect and handle products to site under provisions of Division 1 General Requirements.
B. Protect dampers from damage to operating linkages and blades.

1.8 EXTRA MATERIALS
A. Provide two of each size and type of fusible link.

PART 2 – PRODUCTS

2.1 AIR TURNING DEVICES/EXTRACTORS
A. Multi blade device with blades aligned in short dimension; steel construction; with individually adjustable blades, mounting straps.

2.2 DUCT ACCESS DOORS
A. Fabricate in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated.
B. Fabrication: Rigid and close fitting of galvanized steel with sealing gaskets and quick fastening locking devices. For insulated ductwork, install minimum one-inch thick insulation with sheet metal cover.
   1. Less Than 12 Inches Square: Secure with sash locks.
   2. Up to 18 Inches Square: Provide two hinges and two sash locks.

3. Up to 24 x 48 Inches: Three hinges and two compression latches with outside and inside handles.
4. Larger Sizes: Provide an additional hinge.

C. Access doors with sheet metal screw fasteners are not acceptable.

2.3 DUCT TEST HOLES

A. Temporary Test Holes: Cut or drill in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist on metal caps.
B. Permanent Test Holes: Factory fabricated, air tight flanged fittings with screw cap. Provide extended neck fittings to clear insulation.

2.4 FIRE DAMPERS

A. Manufacturers:
   1. Ruskin.
   2. Vent Products.
   3. Air Balance.
   4. Nailor.
B. Fabricate in accordance with NFPA 90A, and UL 555S and as indicated.
C. Ceiling Dampers: Galvanized steel, 22-gauge frame and 16-gauge flap, two layers 0.125-inch ceramic fiber on top side, and one layer on bottom side for round flaps, with locking clip.
D. Horizontal Dampers: Galvanized steel, 22-gauge frame, stainless steel closure spring, and lightweight, heat retardant non-asbestos fabric blanket. Dynamic type with spring actuated closure. Closure to be against elevated temperature airflow, against minimum 2400 FPM and against 4.5 in. wg. pressure.
E. Curtain Type Dampers: Galvanized steel with interlocking blades. Provide stainless steel closure springs and latches for horizontal installations, closure under air flow conditions. Configure with blades out of air stream except for 1.0-inch pressure class ducts up to 12 inches in height. Dynamic type with spring actuated closure. Closure to be against elevated temperature airflow, against minimum 2400 FPM and against 4.5 in. wg. pressure.
F. Multiple Blade Dampers: 16 gage galvanized steel frame and blades, oil impregnated bronze or stainless-steel sleeve bearings and plated steel axles, 1/8 x 2-inch plated steel concealed linkage, stainless steel closure spring, blade stops, and lock. Closure to be against elevated temperature airflow, against minimum 2400 FPM and against 4.5 in. wg. pressure.
G. Fusible Links: UL 33, separate at 160 degrees F adjustable link straps for combination fire/balancing dampers.
H. Round Dampers: Curtain type in square frame entirely out of air stream with round collar to match duct size on each side.
I. Actuators must be factory installed.

2.5 FLEXIBLE DUCT CONNECTIONS

A. Fabricate in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible, and as indicated.
B. Connector: Fabric crimped into metal edging strip.
   1. Fabric: UL listed fire retardant neoprene coated woven glass fiber fabric to NFPA 90A, minimum density 30 oz. per sq. yd.
   2. Net Fabric Width: Approximately 3 inches wide.
C. Leaded Vinyl Sheet: Minimum 0.55-inch-thick, 0.87 lbs. per sq. ft., 10 dB attenuation in 10 to 10,000 Hz range.

2.6 VOLUME CONTROL DAMPERS

A. Manufacturers:
   1. Ruskin.
   2. Air Balance.
   3. Vent Products.
B. Fabricate in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible and as indicated.

C. Single Blade Dampers: Fabricate for duct sizes up to 6 x 30 inch.
D. Multi Blade Damper: Fabricate of opposed blade pattern with maximum blade sizes 4 x 72". Assemble center and edge crimped blades in prime coated or galvanized channel frame with suitable hardware.
E. End Bearings: Except in round ductwork 12-inches and smaller, provide end bearings. On multiple blade dampers, provide oil impregnated nylon or sintered bronze bearings.
F. Quadrants:
    1. Provide locking, indicating quadrant regulators on single and multi-blade dampers.
    2. On insulated ducts mount quadrant regulators on standoff mounting brackets, bases, or adapters.
    3. Where rod lengths exceed 30-inches provide regulator at both ends.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install accessories in accordance with manufacturer's instructions, NFPA 90A, and follow SMACNA HVAC Duct Construction Standards - Metal and Flexible. Refer to Section 15890 for duct construction and pressure class.
B. Provide duct access doors for inspection and cleaning before and after filters, coils, fans, automatic dampers, at fire dampers, and elsewhere as indicated. Provide minimum 8 x 8-inch size for hand access, 18 x 18-inch size for shoulder access, and as indicated.
C. Provide duct test holes where indicated and required for testing and balancing purposes.
D. Provide fire dampers to match wall fire rating at locations indicated, where ducts and outlets pass through fire rated components, and where required by authorities having jurisdiction. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges. Fire dampers are required at walls:
    1. Building Fire Separations: See Architectural plans for locations.
    2. All mechanical rooms, floor penetrations, electrical rooms, stairs.
    3. ALL floor openings for ductwork.
E. Demonstrate re setting of fire dampers to Owner's representative.
F. Provide flexible connections immediately adjacent to equipment in ducts associated with all fans and motorized equipment and supported by vibration isolators.
G. Provide balancing dampers at points on supply, return, and exhaust systems where branches are taken from larger ducts as required for air balancing. Install minimum 2 duct widths from duct take off.
H. Provide balancing dampers on duct take off to diffusers, grilles, and registers, regardless of whether dampers are specified as part of the diffuser, grille, or register assembly.
I. Install automatic control dampers provided by BAS contractor in the locations indicated on the floor plans.
J. Manual balancing dampers shall be multi blade type for any duct where the dimension perpendicular to the damper blades is greater than 14".

3.2 INSTALLATION OF DIVISION 17 PRODUCTS

A. Install valves, temperature and pressure sensors and other instrumentation in the locations directed by the BAS contractor.
B. Install BAS valves and sensors in the locations shown on the plans.
C. Failure of this contractor to adequately coordinate his work with the BAS contractor shall not be justification for any request for additional payment.
D. This contractor shall include the cost of coordinating and installing related BAS components in his bid.

END OF SECTION

SECTION 15930

AIR TERMINAL UNITS

PART 1 – GENERAL

1.1 SECTION INCLUDES
A. Variable volume terminal units.
B. Variable volume regulators.
C. Integral damper motor operators.
D. Integral hot water heating coils.
E. Controls.

1.2 RELATED WORK
A. Section 15510 - Hydronic Piping.
B. Section 15515 - Hydronic Specialties.
C. Section 15890 - Ductwork.
D. Section 15910 - Ductwork Accessories.
E. Section 15940 - Air Outlets and Inlets.
F. Section 15990 – Mechanical Systems Commissioning.
G. Division 17 – Building Automation System.

1.3 REFERENCES
A. ADC 1062 - Air Distribution and Control Device Test Code.
B. NFPA 70 - National Electrical Code.
C. NFPA 90A - Installation of Air Conditioning and Ventilation Systems.
D. UL 181 - Factory Made Air Ducts and Connectors.

1.4 PERFORMANCE TOLERANCES
A. Bass Performance on test conducted in accordance with ADC 1062.

1.5 SUBMITTALS
A. Submit under provisions of the General Requirements.
B. Shop Drawings: Indicate configuration, general assembly, and materials used in fabrication, and electrical characteristics and connection requirements.
C. Product Data: Provide data indicating configuration, general assembly, and materials used in fabrication. Include catalog performance ratings which indicate air flow, static pressure, and NC designation. Include electrical characteristics and connection requirements.
D. Include schedules listing discharge and radiated sound power level for each of second through sixth octave bands at inlet static pressures of one to 4-inch wg.
E. Manufacturer's Installation Instructions: Indicate support and hanging details, and service clearances required.
F. Contractor shall review all shop drawings prior to submitting them for Architect/Engineer's review. Contractor shall stamp each shop drawing to certify that he has reviewed it. Engineer will not check any shop drawings that Contractor has not stamped with his review certification.

1.6 PROJECT RECORD DOCUMENTS
A. Submit under provisions of the General Requirements.

1.7 OPERATION AND MAINTENANCE DATA
A. Submit under provisions of the General Requirements.
B. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts lists. Include directions for resetting constant volume regulators.

1.8 QUALIFICATIONS
A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum five years documented experience.

1.9 REGULATORY REQUIREMENTS

A. Products Requiring Electrical Connection: Listed and classified by Underwriters' Laboratories Inc., as suitable for the purpose specified and indicated.
B. Conform to 2015 International Mechanical Code and 2018 International Energy Conservation Code.

1.10 DELIVERY, STORAGE AND HANDLING

A. The Contractor will deliver the air terminal boxes to each school. The Contractor will unload the equipment for proper storage per the, General Requirements.
B. Upon receipt of the equipment, the Contractor shall inspect the equipment for damage. The Contractor shall provide a written list to the manufacturer within 48 hours of delivery indicating any damage to the equipment. After this time, it is assumed that all equipment was received in good condition and the equipment is the responsibility of the contractor until the equipment is properly installed in the building.
C. The Contractor shall store all materials shipped to the site in a protected area. If material is stored outside of the building it must be stored off the ground a minimum of 6 inches set on 6 x 6 planks and/or wood pallets. All material must be completely covered with waterproof tarps or visqueen. All duct openings will have the ends closed to keep out dirt and other debris. No equipment will be allowed to be stored on the site unless it is sitting on wood planks and completely protected with waterproof covers.

1.11 WARRANTY

A. Contractor shall provide a one (1) year manufacturer’s warranty on parts on furnished equipment. Equipment parts warranty shall start at time of substantial completion. Contractor will provide a one (1) year warranty on all labor associated with the equipment and its’ installation. Warranty shall start at date of final payment. See General Requirements for additional requirements.

PART 2 – PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Nailor.
B. Titus.
C. Trane.
D. No Substitutions.

2.2 MANUFACTURED UNITS

A. Ceiling mounted variable air volume control terminals for connected to single duct, central air systems, with DDC electronic volume controls, and hot water coils.
B. Identify each terminal unit with clearly marked identification label and air flow indicator. Include unit nominal air flow, and coil type.

2.3 SINGLE DUCT VARIABLE VOLUME UNITS

A. Basic Assembly:
    1. Casings: Minimum 22 gage galvanized steel.
    2. Lining: Galvanized double wall (insulated).
    3. Plenum Air Inlets: Round stub connections or S slip and drive connections for duct attachment.
    4. Plenum Air Outlets: S slip and drive connections.
    5. Control Cabinet.

B. Basic Unit:
   1. Configuration: Air volume damper assembly and fan in series arrangement inside unit casing. Locate control components inside protective metal shroud.
   2. Volume Damper: Construct of galvanized steel with peripheral gasket and self-lubricating bearings; maximum damper leakage: 2 percent of design air flow at 3 inches rated inlet static pressure.
   3. Mount damper operator to position damper normally open.
   4. Bottom access door.
C. Hot Water Heating Coil:
   1. Construction: 1/2-inch copper tube mechanically expanded into aluminum plate fins, leak tested under water to 200 psig pressure, factory installed.
   2. Capacity: Based on 140-degree F entering water.
D. Wiring
   1. Factory mount and wire controls. Mount electrical components in control box with removable cover. Incorporate single point electrical connection to power source. Provide space in control box to incorporate field mounted controls.
   2. Factory mount transformer for control voltage on electric and electronic control units. Provide terminal strip in control box for field wiring of thermostat and power source.
   3. Electrical Characteristics:
      a. Refer to Section 16180.
   4. Wiring Terminations: Wire fan and controls to terminal strip. Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70.

2.4 CONTROLS

A. All controls to be direct digital controls (DDC) furnished by Building Automation System (BAS) Contractor installed on the VAV boxes in the field by the BAS Contractor.
B. Control Manufacturers:
   1. Refer to Division 17.
C. Automatic Damper Operator:
   1. Operate: Air volume damper and automatic volume control.
   2. Velocity Reset Controller and Probe: Electronic with multiple point sensing ring and transducer for air volume control with means for pressure independent compensating for varying inlet static pressure, with minimum and maximum limits set at reset device, mounted in control box.

2.5 FACTORY TESTS

A. Test run volume dampers and controls. Check sequence of operation and air flow limits at factory prior to shipment.
B. Base performance of tests conducted in accordance with ADC 1062.
C. Automatic flow controller shall be capable of maintaining air flow to within 5 percent of setpoint with inlet static pressure variations up to 2 inches.
D. Maximum Casing Leakage: 1 percent of design air flow at 0.5-inch WG static pressure.

2.6 MANUFACTURER'S FIELD SERVICE

A. Provide start-up services in accordance with Division 1 General Requirements.

2.7 EQUIPMENT MANUFACTURER'S COST

A. The equipment manufacturer's price shall include start-up services, operating manuals and warranty for parts and labor on equipment only.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.
B. Provide ceiling access doors at each unit located above a non-accessible ceiling or locate units above easily removable ceiling components.
C. Support units individually from structure. Do not support from adjacent ductwork.
D. Connect to ductwork in accordance with Section 15890.
E. Provide all space temperature sensor controls and field control wiring to make Air Terminal Units fully operational.
F. Provide start-up services and enforce manufacturer's warranty for all moving components on air terminal units.
G. Coordinate services of Air Balancing Contractor to calibrate minimum, maximum and fan flow rates in the field.
H. Provide minimum of 5 feet of one-inch thick lined ductwork downstream of units.
I. Verify that electric power is available and of the correct characteristics.

3.2 ADJUSTING

A. Rating volume with damper operator attached to assembly allowing flow range modulation from 100 percent of design flow to scheduled minimum flow. Set units with heating coils for scheduled minimum flow.
B. Confirm proper operation of damper and control valve for heating units.

3.3 OPERATION AND MAINTENANCE DATA BY INSTALLING CONTRACTOR

A. Contractor shall furnish two (2) hard copies and two (2) electronic copies of equipment manuals, maintenance manuals and repair parts list for all equipment and systems reviewed. See General Requirements for additional requirements.

END OF SECTION

SECTION 15940

AIR OUTLETS AND INLETS

PART 1 – GENERAL

1.1 WORK INCLUDED
A. Registers/Grilles
B. Diffusers
C. Louvers.
D. Relief & Intake roof hoods.

1.2 REFERENCES
A. ADC 1062 - Certification, Rating and Test Manual.
B. AMCA 500 - Test Method for Louvers, Dampers and Shutters.
C. ARI 650 - Air Outlets and Inlets.
D. ASHRAE 70 - Method of Testing for Rating the Air Flow Performance of Outlets and Inlets.
E. SMACNA - HVAC Duct Construction Standard - Metal and Flexible.
F. NFPA 70 - National Electrical Code.
G. NFPA 90A - Installation of Air Conditioning and Ventilating Systems.

1.3 SUBMITTALS
A. Submit under provisions of Division 1 General Requirements.
B. Product Data: Provide data for equipment required for this project. Review outlets and inlets as to size, finish, and type of mounting prior to submission. Submit schedule of outlets and inlets showing type, size, location, application, and noise level.

1.4 PROJECT RECORD DOCUMENTS
A. Record actual locations of air outlets and inlets.

1.5 QUALITY ASSURANCE
A. Test and rate air outlet and inlet performance in accordance with ADC Equipment Test Code 1062 and ASHRAE 70.
B. Test and rate louver performance in accordance with AMCA 500.

1.6 QUALIFICATIONS
A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum five years documented experience.

PART 2 – PRODUCTS

2.1 MANUFACTURERS
A. Carnes.
B. Krueger.
C. Metalaire.
D. Price.
E. Titus.
F. Tuttle and Baily.
G. Nailor.

2.2 SQUARE/RECTANGULAR CEILING DIFFUSERS
A. Type: Square, adjustable pattern, stamped, multi core diffuser to discharge air in 360-degree pattern.
B. Frame: Inverted T bar type. In plaster ceilings, provide plaster frame and ceiling frame.
C. Fabrication: Steel with baked enamel finish selected by Architect.
D. Accessories: Radial opposed blade damper and multi louvered equalizing grid with damper adjustable from diffuser face.

2.3 SUPPLY REGISTERS/GRILLES

A. Type: Aluminum border and individually adjustable blades, ¾-inch blade spacing, single deflection.
B. Frame: 1¼-inch margin with countersunk screw mounting and gasket.
C. Factory baked enamel finish as selected by Architect.
D. Damper: Aluminum opposed blade type, operable from face.

2.4 RETURN GRILLES/REGISTERS

A. Return grilles shall be ½" blade spacing with 0-degree fixed deflection blades. Blades shall be parallel to the long dimension of the grille or register.
B. Construction shall be of steel or aluminum as scheduled with a 1¼" wide border on all sides. Screw holes shall be countersunk for a neat appearance.
C. Deflection blades shall be contoured to a specifically designed and tested cross-section to meet published test data. Blades shall be firmly held in place by mullions from behind the grille and fixed in place by welding.
D. The grille finish shall be baked anodic acrylic paint as selected by the Architect.
E. Opposed blade volume damper shall be constructed of heavy gauge steel, operable from the face of the register.

2.5 HEAVY DUTY BAR RETURN GRILLES

A. Type: Steel bar grilles, ½-inch blade spacing, 38-degree deflection.
B. Frame: 1¼-inch margin with countersunk screw mounting.
C. Fabrication: Steel bars with 14-gauge blades and 16-gauge borders with factory aluminum colored baked enamel finish as selected by the Architect.

2.6 ROUND CEILING DIFFUSERS

A. The round ceiling diffuser shall have three round cones and round neck inlets of the sizes and mounting types shown on the plans and outlet schedule. Two horizontal discharge settings shall allow the diffuser to be field adjusted for different flow rate conditions. The two inner cones must be easily removable as a unit using a spring lock mechanism.
B. Round diffuser shall be constructed of 18-gauge steel. The finish shall be white. The finish shall be an anodic acrylic paint, baked at 315°F for 30 minutes. The pencil hardness must be HB to H.
C. The paint must pass a 100-hour ASTM B117 Corrosive Environments Salt Spray Test without creepage, blistering or deterioration of film. The paint must pass a 250-hour ASTM D870 Water Immersion Test. The paint must also pass the ASTM D2794 Reverse Impact Cracking Test with a 50-inch pound force applied.
D. Round damper shall be constructed of heavy gauge steel. Damper must be operable from the face of the diffuser. A retainer cable shall be provided to allow the inner core assembly to hang during maintenance of diffusers with a neck size of 12 inches or greater.
E. The manufacturer shall provide published performance data for the round diffuser. The diffuser shall be tested in accordance with ANSI/ASHRAE Standard 70-1991.

2.7 LOUVERS

A. Manufacturers:
   1. American Warming.
   2. DowCo.
   3. Greenheck.
   4. Ruskin Mfg.
   5. Vent Products.
B. Type: 4-inch-deep, drainable with blades on 37.5-degree slope with a drain gutter in each blade and downspouts in frame jambs and mullions, heavy channel frame, birdscreen with ½-inch square mesh for exhaust and ¾-inch for intake.

C. Fabrication: 12-gauge thick extruded aluminum, welded assembly, with factory clear anodized finish, color to be selected by the Architect. Design shall incorporate structural supports required to withstand a wind load of 20 lbs. per sq. ft.
D. Design Basis Performance (based on 60” x 10” DowCo DWE-04):
   1. Maximum face velocity of free area: 750 fpm.

2.8 ROOF HOODS

A. Manufacturers:
   1. Cook.
   2. Carnes.
   3. Greenheck.
   4. Twin City Fans.
B. Fabricate air inlet or exhaust hoods in accordance with SMACNA HVAC Duct Construction Standards - Metal and Flexible.
C. Fabricate of aluminum minimum 14-gauge base and 14-gauge hood; suitably reinforced; with hinged hood; birdscreen with ½-inch square mesh for exhaust and ¾-inch for intake, and clear anodized finish. All vertical seams shall be continuously welded with lock formed seams on the hood ends. Hoods shall be stressed and sloped for drainage.
D. Fabricate louver penthouses with mitered corners and reinforce with structural angles.
E. Mount unit on minimum 18-inch-high curb base with insulation between duct and curb.
F. Make hood outlet area minimum of twice throat area.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.
B. Check location of outlets and inlets and make necessary adjustments in position to conform with architectural features, symmetry, and lighting arrangement.
C. Install diffusers to ductwork with air tight connection.
D. Provide balancing dampers on duct take off to diffusers, and grilles and registers, despite whether dampers are specified as part of the diffuser, or grille and register assembly.
E. Paint ductwork visible behind air outlets and inlets matte black.
F. Backpaint louver frames with bituminous paint before installation.
G. Secure louvers to wall openings with exposed stainless-steel fasteners 12 in. on center.
G. Caulk louver frames watertight. Entire installation shall be watertight under all weather conditions.

END OF SECTION

SECTION 15990

MECHANICAL SYSTEMS COMMISSIONING

PART 1 - GENERAL

1.1 DESCRIPTION

A. The purpose of this section is to provide a guide for the Contractor/Seller to specify the Division 15 and Division 17 responsibilities in the commissioning process.
B. The systems to be commissioned are listed in the Contract Documents.
C. Commissioning requires the participation of Division 15 and Division 17 to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Division 01. Division 15 and Division 17 shall be familiar with all parts of Division 01 and the commissioning plan issued by the CA and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

1.2 RELATED SECTIONS

A. Refer to Division 01 for a listing of all sections where commissioning requirements are found.
B. Refer to Division 01 for systems to be commissioned.

1.3 SUBMITTALS

A. Division 15 and Division 17 shall provide submittal documentation relative to commissioning as required in this Section Part 1.

1.4 RESPONSIBILITIES

A. Mechanical, Controls and TAB Contractors. The commissioning responsibilities applicable to each of the mechanical, controls and TAB Contractors of Division 15 and Division 17 are as follows (all references apply to commissioned equipment only):
    1. Construction and Acceptance Phases
        a. Include and itemize the cost of commissioning in the contract price.
        b. Attend a commissioning scoping meeting and other meetings necessary to facilitate the commissioning process.
        c. Contractors shall provide the Commissioning Act (CA) with normal cut sheets and shop drawing submittals of commissioned equipment.
        d. Provide additional requested documentation, prior to normal O & M manual submittals, to the CA for development of start-up and functional testing procedures.
            1) Typically, this will include detailed manufacturer installation and start-up, operating, troubleshooting and maintenance procedures, full details of any owner-contracted tests, fan and pump curves, full factory testing reports, if any, and full warranty information, including all responsibilities of the Owner to keep the warranty in force clearly identified. In addition, the installation, start-up, and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Commissioning Agent.
            2) The Commissioning Agent may request further documentation necessary for the commissioning process.
            3) This data request may be made prior to normal submittals.
        e. Provide a copy of the O & M manuals and submittals of commissioned equipment, through normal channels, to the CA for review and approval.
        f. Contractors shall assist (along with the design engineers) in clarifying the operation and control of commissioned equipment in areas where the specifications control drawings or equipment documentation is not sufficient for writing detailed testing procedures.
        g. Provide limited assistance to the CA in preparing the specific functional performance test procedures required. Sub-Contractors shall review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.
        h. Develop a full start-up and initial check out plan using manufacturers start-up procedures and the pre-functional checklists from the CA for all commissioned equipment. Submit to CA for review and approval prior to startup.

i. During the startup and initial checkout process, execute the mechanical related portions of the pre-functional checklists for all commissioned equipment.
j. Perform and clearly document all completed startup and system operational checkout procedures, proving a copy to the CA.
k. Address current A/E punch list items before functional testing. Air and water TAB shall be completed with discrepancies and problems remedied before functional testing of the respective air- or water-related systems.
l. Provide skilled technicians to execute starting of equipment and to execute the functional performance tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem solving.
m. Perform functional performance testing under the direction of the CA for specified equipment. Assist the CA in interpreting the monitoring data, as necessary.
n. Correct deficiencies (differences between specified and observed performance) as interpreted by the CA, Engineer and Architect and retest the equipment.
o. Prepare O & M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.
p. Prepare redline as-built drawings for all drawings and final as-builds for Contractor-generated coordination drawings.
q. Provide training of the Owner's operating personnel as specified.
r. Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

2. Warranty Period
   a. Execute seasonal or deferred functional performance testing, witnessed by the CA, according to the specifications.
   b. Correct deficiencies and make necessary adjustments to O & M manuals and as-built drawings for applicable issues identified in an seasonal testing.

B. Mechanical Contractor. The responsibilities of the HVAC mechanical Contractor, during construction and acceptance phases in addition to those listed in (A) are:
   1. Provide startup for all HVAC equipment.
   2. Assist and cooperate with the TAB Contractor and CA by:
      a. Putting all HVAC equipment and systems into operation and continuing the operation during each working day of TAB and commissioning, as required.
      b. Including costs of sheaves and belts that may be required by TAB.
      c. Providing test holes in ducts and plenums where directed by TAB to allow air measurements and air balancing. Providing an approved plug.
      d. Providing temperature and pressure taps according to the Construction Documents for TAB and commissioning testing.
   3. Install a P/T plug at each water sensor that is an input point to the control system.
   4. List and clearly identify on the as-built drawings the locations of all airflow stations.
   5. Prepare a preliminary schedule for Division 15 pipe and duct system testing, flushing and cleaning, equipment start-up and TAB start and completion for use by the CA. Update the schedule as appropriate.
   6. Notify the Engineer or CA, depending on protocol, 5 working days prior to the time scheduled when pipe and duct system testing, flushing, cleaning, startup of each piece of equipment and TAB will occur. Be responsible to notify the Engineer or CA, ahead of time, when commissioning activities not yet performed or not yet scheduled will delay construction. Be proactive in seeing that commissioning processes are executed and that the CA has the scheduling information needed to efficiently execute the commissioning process.

C. Mechanical Contractor. The responsibilities of the HVAC mechanical Contractor, during construction and acceptance phases in addition to those listed in (A) are:
   1. Controls Contractor. (As Sub-Contractor to the Mechanical Contractor) The commissioning responsibilities of the controls Contractor, during construction and acceptance phases in addition to those listed in (A) are:
      a. Sequence of Operation Submittals. The Controls Contractor's submittals of control drawings shall include complete detailed sequences of operation for each piece of equipment, regardless of the completeness and clarity of the sequences in the specifications. They shall include:
      b. An overview narrative of the system (1 or 2 paragraphs) generally describing its purpose, components, and function.
      c. All interactions and interlocks with other systems.
      d. Detailed delineation of control between any packaged controls and the building automation system, listing what points the BAS monitors only and what BAS points are control points and are adjustable.
      e. Written sequences of control for packaged controlled equipment (equipment manufacturers' stock sequences may be included, but will generally require additional narrative).
      f. Start-up sequences.
      g. Warm-up mode sequences.
      h. Normal operating mode sequences.
      i. Unoccupied mode sequences.
      j. Shutdown sequences.
      k. Capacity control sequences and equipment staging.
      l. Temperature and pressure control: setbacks, setups, resets, etc.
      m. Detailed sequences for all control strategies, e.g., economizer control, optimum start/stop, staging, optimization, demand limiting, etc.
      n. Effects of power or equipment failure with all standby component functions.
      o. Sequences for all alarms and emergency shut downs.
      p. Seasonal operational differences and recommendations.
      q. Initial and recommended values for all adjustable settings, set-points and parameters that are typically set or adjusted by operating staff; and any other control settings or fixed values, delays, etc. that will be useful during testing and operating the equipment.
      r. Schedules, if known.
      s. All sequences shall be written in small statements, each with a number for reference. For a given system, numbers will not repeat for different sequence sections, unless the sections are numbered.
   2. Control Drawings Submittal
      a. The control drawings shall have a key to all abbreviations.
      b. The control drawings shall contain graphic schematic depictions of the system and each component.
      c. The schematics will include the system and component layout of any equipment that the control system monitors, enables or controls, even if the equipment is primarily controlled by packaged or integral controls.
      d. Provide a full points list with at least the following included in each point:
         1) Controlled system.
         2) Point abbreviation.
         3) Point description.
         4) Display unit.
         5) Control point or set-point (Yes / No).
         6) Monitoring point (Yes / No)
         7) Intermediate point (Yes / No)
         8) Calculated Point (Yes / No)

3. Key:
   a. Point Description: DB temp, airflow, etc.
   b. Control or Set-Point: Point that controls equipment and can have its set-point changed (OSA, SAT, etc.)
   c. Intermediate Point: Point whose value is used to make a calculation which then controls equipment (space temperatures that are averaged to a virtual point to control reset).
   d. Monitoring Point: Point that does not control or contribute to the control of equipment, but is used for operation, maintenance, or performance verification.
   e. Calculated Point: “Virtual” point generated from calculations of other point values.
   f. The Controls Contractor shall keep the CA informed of all changes to this list during programming and setup.
4. An updated as-built version of the control drawings and sequences of operation shall be included in the final controls O & M manual submittal.
5. Assist and cooperate with the TAB Contractor in the following manner:
   a. Meet with the TAB Contractor prior to beginning TAB and review the TAB plan to determine the capabilities of the control system toward completing TAB. Provide the TAB any needed unique instruments for setting terminal unit boxes and instruct TAB in their use (handheld control system interface for use around the building during TAB, etc.)
   b. For a given area, have all required pre-functional checklists, calibrations, start-up and selected functional tests of the system completed and approved by the CA prior to TAB.
   c. Provide a qualified technician to operate the controls to assist the TAB Contractor in performing TAB, or provide sufficient training for TAB to operate the system without assistance.
6. Assist and cooperate with the CA in the following manner:
   a. Execute the functional testing of the controls system as specified for the controls Contractor.
   b. Assist in the functional testing of all equipment specified to be commissioned.
   c. Execute all control system trend logs.
7. The controls Contractor shall prepare a written plan indicating in a step-by-step manner, the procedures that will be followed to test, checkout and adjust the control system prior to functional performance. At minimum, the plan shall include for each type of equipment controlled by the automatic controls:
   a. System name.
   b. List of devices.
   c. Step-by-step procedures for testing each controller after installation, including:
      1) Process of verifying proper hardware and wiring installation.
      2) Process of downloading programs to local controllers and verifying that they are addressed correctly.
      3) Process of performing operational checks of each controlled component.
      4) Plan and process for calibrating valve and damper actuators and all sensors.
      5) A description of the expected field adjustments for transmitters, controllers, and control actuators should control responses fall outside of expected values.
   d. A copy of the log and field checkout sheets that will document the process. This log must include a place for initial and final read values during calibration of each point and clearly indicate when a sensor or controller has “passed” and is operating within the contract parameters.
   e. A description of the instrumentation required for testing.
   f. Indicate what tests on what systems should be completed prior to TAB using the control system for TAB work. Coordinate with the CA and TAB Contractor for this determination.

8. Provide a signed and dated certification to the CA and Engineer upon completion of the checkout of each controlled device, equipment, and system prior to functional testing for each piece of equipment or system programming is complete as to all respects of the Contract Documents, except functional testing requirements.
9. Beyond the control points necessary to execute all documented control sequences, provide monitoring, control and virtual points as specified.
10. List and clearly identify on the as-built duct and piping drawings the locations of all static and differential pressure sensors (air, water and building pressure).

D. TAB Contractor: The duties of the TAB Contractor, in addition to those listed in (A) are:
1. Six weeks prior to starting TAB, submit to the Engineer the qualifications of the site technician for the project, including the name of the Contractors and facility managers of recent projects the technicians on which was lead. The Engineer will approve the site technician's qualifications for this project.
2. Submit the outline of the TAB plan and approach for each system and component to the CA, Engineer, and the controls Contractor six weeks prior to starting the TAB. This plan will be developed after the TAB has some familiarity with the control system.
3. The submitted plan will include:
   a. Certification that the TAB Contractor has reviewed the construction documents and the systems with the design engineers and Contractors to sufficiently understand the design intent for each system.
   b. An explanation of the intended use of the building control system. The controls Contractor will comment on feasibility of the plan.
   c. All field checkout sheets and logs to be used that list each piece of equipment to be tested, adjusted, and balanced with the data cells to be gathered for each.
   d. Discussion of what notations and markings will be made on the duct and piping drawings during the process.
   e. Final test reports forms to be used.
   f. Detailed step-by-step procedures for TAB work for each system and issue: terminal flow calibration (for each terminal type), diffusers proportioning, branch/sub-main proportioning, total flow calculations, rechecking, diversity issues, expected problems and solutions, etc. Criteria for using airflow straighteners or relocating flow stations and sensors will be discussed. Provide the analogous explanations for the waterside.
   g. List of all air flow, water flow, sound level, system capacity and efficiency measurements to be performed and a description of specific test procedures, parameters, formulas to be used.
   h. Details of how total flow will be determined (Air: sum of terminal flows via BAS calibrated readings or via hood readings of all terminal, supply (SA) and return air (RA) pitot traverse, SA or RA flow stations. Water: pump curves, circuit setter, flow station, ultrasonic, etc.)
   i. The identification and types of measurement instruments to be used and their utmost recent calibration date.
   j. Specific procedures that will ensure that both air and water side are operating at the lowest possible pressures and provide methods to verify this.
   k. Confirmation that TAB understands the outside air ventilation criteria under all conditions.
   l. Details of whether and how minimum outside air cfm will be verified and set, and for what level (total building, zone, etc.)
   m. Details of how building static and exhaust fan/relief damper capacity will be checked.
   n. Proposed selection points for sound measurements and sound measurement methods.
   o. Details of methods for making any specified coil or other system plan capacity measurements.
   p. Details of any TAB work to be done in phases (by floor, etc.). or of areas to be built out later.
   q. Details regarding specified deferred or seasonal TAB work.
   r. Details of any specified false loading of systems to complete TAB work.

s. Details of all exhaust fan balancing and capacity verifications, including any required room pressure differentials.
t. Details of any required interstitial cavity differential pressure measurements and calculations.
u. Plan for hand-written field technician logs of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests (scope and frequency).
v. Plan for formal progress reports (scope and frequency).
w. Plan for formal deficiency reports (scope, frequency and distribution).

4. A running log of events and issues shall be kept by the TAB field technicians. Submit hand-written reports of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests to the CA and Engineer at least twice a week.
5. Communicate in writing to the controls Contractor all set point and parameter changes made or problems and discrepancies identified during TAB which affect the control system setup and operation.
6. Provide a draft TAB report within two weeks of completion. A copy will be provided to the CA. The report will contain a full explanation of the methodology, assumptions, and the results in a clear format with designations of all uncommon abbreviations and column headings. The report should follow the latest and most rigorous reporting recommendations by AABC, NEBB or ASHRAE Standard 111.
7. Provide the CA with any requested data, gathered, but not shown on the draft reports.
8. Provide a final TAB report for the CA with details, as in the draft.
9. Conduct functional performance tests and checks on the original TAB as specified for TAB in Section 17800.

PART 2 - PRODUCTS

2.1 TESTING EQUIPMENT

A. Division 15 and Division 17 shall provide all test equipment necessary to fulfill the testing requirements of this Division.
B. For additional requirements refer to Division 15 and Division 17.

PART 3 - EXECUTION

3.1 START UP

A. The HVAC mechanical and controls Contractors shall follow the start-up and initial checkout procedures listed in the Responsibilities list in this section. Division 15 and Division 17 has start-up responsibility and is required to complete systems and subsystems so they are fully functional, meeting the design objectives of the Contract Documents. The commissioning procedures and functional testing do not relieve or lessen this responsibility or shift that responsibility partially to the commissioning agent or Owner.
B. Functional testing is intended to being upon completion of a system. Functional testing may proceed prior to the completion of systems or sub-systems at the discretion of the CA and Engineer. Beginning system testing before full completion, does not relieve the Contractor from fully completing the system, including all pre-functional checklists as soon as possible.

3.2 TESTING, ADJUSTING AND BALANCING (TAB)

A. Refer to the TAB responsibilities in Part 1.2 above.

3.3 FUNCTIONAL PERFORMANCE TESTS

A. Functional Performance Test shall be provided for the following systems to be commissioned:
   1. All exhaust systems.
   2. Kitchen hood exhaust air system.

3. HVAC pumps.
4. Condensing firetube boilers.
5. Pre-purchased indoor condenserless liquid water chiller with remote condenser.
6. Terminal heat transfer units – hot water.
7. Air handling units.
8. Air terminal units.
9. Air-Cooled Condensing Units.
10. Domestic hot water heater and thermostatic mixing valve.

3.4 OPERATION AND MAINTENANCE (O & M) MANUALS

A. The following O & M manual requirements do not replace O & M manual documentation requirements elsewhere in these specifications.
B. Division 15 and Division 17 shall compile and prepare documentation for all equipment and systems covered in Division 15 and Division 17 and deliver this documentation to the CONTRACTOR for inclusion in the O & M manuals, according to this section, prior to the training of owner personnel.
C. The CA shall receive a copy of the O & M manuals for review.
D. Special Control System O & M Manual Requirements. In addition to documentation that may be specified elsewhere, the controls Contractor shall compile and organize at minimum the following data on the control system in labeled 3-ring binders with indexed tabs.
    1. Operation and Maintenance Manuals containing:
        a. Specific instructions on how to perform and apply all functions, features, modes, etc. mentioned in the controls training sections of this specification and other features of this system. These instructions shall be step-by-step. Indexes and clear tabs of contents shall be included. The detailed technical manual for programming and customizing control loops and algorithms shall be included.
        b. Full as-built set of control drawings (refer to Submittals section above for details.)
        c. Full as-built sequence of operations for each piece of equipment.
        d. Full points list. In addition to the updated points list required in the original submittals (Part 1 of this section), a listing of all rooms shall be provided with the following information for each room:
            1) Floor.
            2) Room number.
            3) Room name.
            4) Air handler unit ID.
            5) Reference drawing number.
            6) Air terminal unit tag ID.
            7) Heating and/or cooling valve tag ID.
            8) Minimum cfm.
            9) Maximum cfm.
        e. Full print out of all schedules and set points after testing and acceptance of the system.
        f. Full as-built print out of software program.
        g. Electronic copy on disk of the entire program for this facility.
        h. Marking of all system sensors and thermostats on the as-built floor plan and mechanical drawings with their control system designations.
        i. Maintenance instructions, including sensor calibration requirements and methods by sensor type, etc.
        j. Control equipment component submittals, parts lists, etc.
        k. Warranty requirements.
        l. Copies of all checkouts tests and calibrations performed by the Contractor (not commissioning tests).
    2. The manual shall be organized and subdivided with permanently labeled tabs for each of the following data in the given order:
        a. Sequences of operation.
        b. Control drawings.

c. Points lists.
d. Controller / module data.
e. Thermostats and timers.
f. Sensors and DP switches.
g. Valves and valve actuators.
h. Dampers and damper actuators.
i. Program setups (software program printouts).

3. Field checkout sheets and trend logs should be provided to the CA for inclusion in the Commissioning Record Book.

E. Special TAB Documentation Requirements. The TAB will compile and submit the following with other documentation that may be specified elsewhere in the Specifications.
1. Final report containing an explanation of the methodology, assumptions, test conditions and the results in a clear format with designations of all uncommon abbreviations and column headings.
2. The TAB shall mark on the drawings where all traverse and other critical measurements were taken and cross-reference the location in the TAB report.

F. Review and Approvals. Review of the commissioning related sections of the O & M manuals shall be made by the A/E and by the CA.

3.5 TRAINING

A. The Contractor shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed.
B. The CA shall be responsible for overseeing and approving the content and adequacy of the training of Owner personnel for commissioned equipment or systems.
C. Mechanical Contractor. The mechanical contractor shall have the following training responsibilities:
1. Provide the CA with a training plan two-weeks before the planned training.
2. Provide designated Owner personnel with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each piece of HVAC equipment including, but not limited to pumps, boilers, furnaces, chillers, heat rejection equipment, air conditioning units, air handling units, fans, terminal units, controls and water treatment systems, etc.
3. Training shall normally start with classroom sessions followed by hands-on training on each piece of equipment, which shall illustrate the various modes of operation, including startup, shutdown, fire/smoke alarm, power failure, etc.
4. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.
5. The appropriate trade or manufacturer’s representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing Contractor or manufacturer’s representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment is required. More than one party may be required to execute the training.
6. The controls Contractor shall attend sessions other than the controls training, as requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.
7. The training sessions shall follow the outline in the Table of Contents of the operation and maintenance manual and illustrate whenever possible the use of the O & M manuals for reference.
8. Training shall include:
a. Use of the printed installation, operation and maintenance instruction material included in the O&M manuals.
b. A review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts

inventory suggestions. The training shall include start-up, operation in all modes possible, shutdown, seasonal changeover, and any emergency procedures.
c. Discussion of relevant health and safety issues and concerns.
d. Discussion of warranties and guarantees.
e. Common troubleshooting problems and solutions.
f. Explanatory information included in the O&M manuals and the location of all plans and manuals in the facility.
g. Discussion of any peculiarities of equipment installation or operation.
h. The format and training agenda in The HVAC Commissioning Process, ASHRAE Guideline 1-1989R, 1996 is recommended.

9. Hands-on training shall include start-up, operation in all modes possible, including manual, shutdown and any emergency procedures and preventative maintenance for all pieces of equipment.
10. The mechanical Contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not controlled by the central control system.
11. Training shall occur after functional testing is complete, unless approved otherwise by the Project Manager.

D. Controls Contractor. The controls Contractor shall have the following training responsibilities:
1. Provide the CA with a training plan four-weeks before the planned training.
2. The controls contractor shall provide designated Owner personnel training on the control system in this facility. The intent is to clearly and completely instruct the Owner on all the capabilities of the control system.
3. The training will be tailored to the needs and skill-level of the trainees.
4. The trainers will be knowledgeable on the system and its use in buildings. For the on-site sessions, the most qualified trainer(s) will be used. The Owner shall approve the instructor prior to scheduling the training.
5. During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operation, the system will be repaired or adjusted as necessary and the demonstration repeated.
6. The controls Contractor shall attend sessions other than the controls training, as requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.

3.6 WRITTEN WORK PRODUCTS

A. Written work products of Contractors will consist of a start-up and initial checkout plan and a completed start-up, initial checkout, and pre-functional checklists.

END OF SECTION

SECTION 16010

BASIC ELECTRICAL REQUIREMENTS

PART 1 – GENERAL

1.1 WORK INCLUDED

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and the General Requirement Specification, apply to this and the other sections of Division 16.
B. The Section is hereby made a part of all other sections of Division 16 as fully as if repeated in each therein.

1.2 SECTION INCLUDES

A. Descriptions.
B. Quality assurance.
C. Codes.
D. Approvals.
E. Permits and inspections.
F. Fees.
G. Submittals.
H. Instruction.
I. Overtime
J. Alternates
K. Guarantees.
L. Warranty.
M. Products
N. Execution.

1.3 RELATED SECTIONS

A. Substitutions: Refer to the General Requirements and 16 Sections.
B. Shop Drawings: Refer to the General Requirements and 16 Sections.
C. Operation and Maintenance Data: Refer to the General Requirements and 16 Sections.
D. Coordination with Other Trades: Refer to the General Requirements, 15, and1 16 Sections.

1.4 DEFINITIONS

A. Provide all required products and execution for a complete and fully operational Electrical System. Such work includes, but is not limited to, that which is identified on the contract documents. For the purpose of this specification, the following terms are defined:
    1. “Contract documents” include the most current project drawings and specification.
    2. “Provide” includes furnishing and installation.
    3. “Furnish” includes purchasing and transporting new equipment, as specified, to the job site.
    4. “Install” includes mounting or setting equipment in place, in specified location, making all required electrical connections for a working product.
    5. “Electrical System” includes all distribution of power, lighting, fire protection, life safety, communications, security, special systems, and any other information, electrical in nature, identified on the Contract Documents, from the point(s) of service to utilization device(s).
    6. “Connecting” means providing a power source, overcurrent devices, raceways, conductors, terminations, insulation supports, and other materials and equipment required for the operation and control of the relevant operation.
B. Provide materials, equipment, installation or testing identified on the drawings but not specified herein; or that which is specified herein, but not identified on the drawings shall be provided at no additional cost to the Owner.
C. Provide materials or equipment including minor items, accessories, or devices reasonably inferable as necessary for the completion and proper operation of any systems or products identified on the Contract Documents.

1.5 QUALITY ASSURANCE

A. Discovery of any conflicting design information or any design intentions which are not readily interpreted shall be referred to the Architect/Engineer for further description or illustration prior to any product selection or execution of work.
B. Discovery of any materials or equipment which are damaged, unsuitable, incompatible, or non-compliant with any applicable codes, laws, ordinances, or other regulations shall be brought to the direct attention of the Architect/Engineer.
C. Generally, the Drawings establish the location, quantity and relationship of the parts of the work, and the specifications define the type and quality of materials and workmanship. Work shown in the drawings and not mentioned in the specifications or required by the specifications and not shown on the drawings, shall be provided as if fully provided for in both. In the case of conflicts between the drawings and specifications, or within either document, the Architect/Engineer shall determine the intent. In such cases, in general, the more stringent requirement concerning greater quantity, quality, and/or resulting in a higher cost shall govern without further cost to the Owner.
D. The equipment list contained in this specification includes only the major equipment requirements. Verify the completeness and suitability of device to meet the intent of the specifications. Any additional equipment required, even if not specifically mentioned herein, shall be provided without claim for additional payment; it being understood that a complete operating system, satisfactory to the Engineer and the Owner, is required in all cases.

1.6 REGULATORY REQUIREMENTS

A. Where governing codes indicate the Drawings and Specifications do not comply with the minimum requirements of applicable codes, the Contractor shall either notify the Architect/Engineer in writing during the bidding period identifying the revisions required to meet code requirements or provide an installation which will comply with the code requirements.
B. All material, equipment, installation, and testing should be in accordance with all applicable codes, laws, and ordinances of Federal, State and local governing bodies having jurisdiction.
C. In case of differences between building codes, Federal and State laws, local ordinances and utility company regulations and the Contract Documents, the most stringent shall govern.
D. Where any materials, equipment or installation is not in compliance with the more stringent of the applicable codes, laws, ordinances, regulations, and contract documents, they shall be entirely removed, replaced, modified, or otherwise corrected at no additional cost to the Owner.
E. Materials, equipment, installation, and testing shall conform to the latest editions of the applicable following codes:
    1. BOCA - Building Officials and Code Administrators.
    2. NEC - National Electrical Code.
    3. State of Illinois Building Code.
    4. NFPA 72 - National Fire Protection Association
    5. IBC - International Building Code 2015.
F. All product materials and work shall comply with all local codes, including but not limited to the following codes and standards as applicable, in addition to any codes and standards referenced within individual specification sections. These codes and standards shall apply to all Division 26 Sections as applicable.
    1. ANSI - American National Standards Institute.
    2. ASTM - American Society for Testing Materials.
    3. CBM - Certified Ballast Manufacturers.
    4. ETL - Electrical Testing Laboratories.
    5. IEEE - Institute of Electrical and Electronic Engineers.
    6. NBS - National Bureau of Standards.
    7. NEMA - National Electrical Manufacturer’s Association.
    8. NFPA - National Fire Protection Association.
    9. OSHA - Occupation Safety and Health Act.
    10. UL - Underwriters Laboratories.

11. ADA - Americans with Disabilities Act.
12. BOCA - National Building Code (1996).
13. NEC - National Electrical Code.
14. IBC - International Building Code.
15. IEC - International Electrical Code.
16. IFC - International Fire Code.

G. Where a UL standard is available, the equipment supplied for the project shall be UL listed and shall bear the UL label.
H. Notify the Architect/Engineer of any materials or apparatus believed to be inadequate, unsuitable, in violation of laws, ordinances, rules or regulations of authorities having jurisdiction.
I. In every installation where regulations of electric utility, telephone and cable TV companies apply, conformance with their regulations is mandatory and any costs involved shall be included in the Contract, with the exception of extra facility and other charges which are directly paid by the Owner.

1.7 APPROVALS

A. Prepare shop drawings and obtain approvals from inspection authorities for emergency and exit lighting, fire alarm and life safety systems, and other electrical installations requiring specific approval.
B. Prepare shop drawings and obtain approvals from governmental agencies and utility companies for applicable electrical installations requiring approval.
C. Copies of the final approved drawings shall be delivered to the Architect/Engineer. Approvals shall be obtained before commencement of related work.

1.8 PERMIT AND INSPECTION

A. Permit: Obtain and pay for all permits, bonds, license, tap-in fees, etc. Required by the City, State, or other authority having jurisdiction over the work.
B. Inspections: Arrange and pay for all inspections required by the above when they become due as part of the work of sections affected. Conceal no work until approved by these governing authorities.
C. Engineer inspections include one above ceiling review and report before ceiling conceal work, one substantial review report and one final review report. All additional review reports required due to incomplete or non-acceptance of substantial or final conditions will require the contractor to pay the engineer $650.00 per additional inspection review and report.

1.9 FEES

A. Pay fees and other charges incidental to electrical work and obtain and pay for required insurance, permits, licenses, inspections and taxes. Arrange for required inspections and delivery certificates and approvals for same to the Architect/Engineer.

1.10 SUBMITTALS

A. Shop Drawings: As soon as practical and before any material or equipment is purchased, the Contractor shall submit shop drawings. A complete list in one category (example: all fixtures) of all shop drawings catalog cuts, material lists, etc. are to be submitted by this Contractor at one time. No consideration will be given to partial shop drawings submitted from time to time.
    1. Extended time for submitting special shop drawings may be requested; however, any extension of time approved does not relieve this Contractor of his responsibility of executing his work in accordance with this contract.
    2. Any listed materials, fixtures, apparatus, or equipment that are not in accordance with specifications requirements can and will be rejected for use in this installation and construction. Substitutions will not be permitted.
    3. Any materials, fixtures, apparatus or equipment installed without stamped or written approval shall be removed by the Contractor and replaced with specified equipment at the direction of the Architect/Engineer and without recourse for additional compensation.

4. Review of shop drawings does not relieve the Contractor from any responsibility for deviation from the Contract Documents unless the deviation is specifically identified on the shop drawings.
5. Contractor shall review and coordinate all shop drawings prior to submitting them for Architects/ Engineer's review. Contractor shall stamp each shop drawing to certify that all MEP related contractors have coordinated and reviewed it. Engineer will not check any shop drawings that Contractor has not stamped with his review certification. Shop drawings will be reviewed once. If a second or third review is required, the contractor will pay the engineer $500.00 per review.
6. Prior to ordering any switchboard, distribution panels, panelboards, or transformers, the contractor shall submit dimension drawings showing the switchboard will fit in the location shown on the drawings. In the event of conflicts, the contractor shall request a written clarification from the Architect/Engineer.

B. Coordination and Installation Drawings:
1. In addition to the preparation and submittal of Shop Drawings and product data for manufactured electrical equipment and materials, prepare and maintain in current status, a complete set of detailed, completely circuited, and dimensioned electrical coordination and record drawings for electrical work included under the Contract. Must include main conduit runs.
2. Coordination and installation drawings shall be made at the Contractor's expense on basic floor plan background. Electronic copies of the electrical drawings may be purchased from the Engineer for $250.00 a copy.
3. Coordination and installation drawings shall be CAD drawings compatible with AutoCAD Version 2012 on the same size and with the same border lines and title blocks as the Architect/ Engineer's Drawings, with the Contractor's name added.
4. Coordinate electrical work with the work of all other trades affecting the electrical work and in preparing the coordination drawings; coordinate the work of other trades in order to avoid possible installation conflicts, which includes but is not limited to mechanical equipment and architectural design elements. In the event of conflicts, interferences or discrepancies that are discovered during the coordination phase of the project, the contractor shall request a written clarification from the Architect/Engineer. If conflicts, interferences or discrepancies arise after the coordination phase of the project and no written clarification was requested, then the work shall be removed, replaced, modified or otherwise corrected at no additional cost to the owner.
5. Record drawings shall indicate the electrical installation exactly as constructed and shall be periodically revised to reflect all changes, including those required by the Architect/Engineer, those which are or have been found necessary in the field and those which may be suggested by the Contractor and accepted by the Architect/Engineer. Drawings shall be revised when considered necessary by the Architect/Engineer or the Contractor in order to facilitate proper coordination.
6. If, in the opinion of the Architect/Engineer, the drawings are in acceptable condition after each has been finally revised, they may be submitted as the field record drawings.
7. Electrical contractor shall verify total connected load/HP with mechanical contractor prior to the installation of conduit and wiring of any mechanical or plumbing equipment. If any work is installed prior to verifying the load/HP of the mechanical or plumbing equipment, the contractor shall remove, replace, modify or otherwise correct the work at no additional cost to the Owner. Make any changes to overcurrent devices or feeder size per the local authority having jurisdiction.

8. Coordination and installation drawings shall be made under the direction and supervision of the Contractor and shall show all electrical work including conduit, wiring, electrical equipment and devices, lighting fixture locations and elevations, points where conduit enters or leaves structural slabs and walls, junction boxes, conduit supports and inserts. The complete electrical distribution system from source or sources up to and including each branch circuit panelboard shall be shown and dimensioned with feeders located on plan. Major equipment and apparatus shall be shown to scale and properly located. Drawings shall also show exact locations and depths of underground conduits and ducts and their terminations.
9. The Drawings shall include floor plan and reflected ceiling plan electrical layouts. Similar drawings of each trade shall be of the same scale in order to permit respective plans to be superimposed upon all others. Drawing shall be prepared and submitted for coordination and review.
10. Initial copy of all drawings shall be submitted for review. These submittals shall not be considered as shop drawings. Subsequent revised copies need not be issued to the Architect/Engineer unless so requested. It shall be clearly understood that these drawings are for installation coordination purposes only and cannot in any way alter the requirements of the Contract Documents. The Contract Documents, Specifications, and authorized revisions thereto, shall remain the only determinants of contract requirements.
11. Upon completion of the drawings and any revisions they shall be dated and certified by Contractor as having been fully coordinated. The work shown upon the completed drawings shall then be considered ready for construction.
12. Electrical work shall not begin until the drawings are certified and reviewed by the Architect/Engineer.
13. Drawings shall be made in accordance with a schedule prepared by the Contractor and arranged to coincide with actual construction in a manner to allow the construction to proceed without delay.
14. If, in the opinion of the Architect/Engineer, the drawings are in acceptable condition after all revisions, they may be submitted as the project “As-Built” drawings.
15. Provide “as-built” drawings.

C. Operation and Maintenance Data: Refer to the General Requirements and Division 26 Sections. Submit four copies of maintenance manuals in hardbound covers containing approved shop drawings and manufacturer’s repair manuals, guarantees, operating instructions, wiring diagram and part lists.

1.11 OPERATION AND MAINTENANCE INSTRUCTION

A. Provide operation and maintenance instruction for equipment and systems.

1.12 OVERTIME WORK

A. All construction work shall be done on regular working hours and days, unless otherwise specified. If overtime work, other than specified, is required on the project, it shall be performed as indicated.
B. System shutdown shall occur during off business hours and shall be done on over-time basis.
C. The base bid shall include overtime work specified. No compensation shall be made for other work done on overtime basis, unless authorized.

1.13 ALTERNATES

A. Accepted alternates, if any, may affect portions of the Base Bid Work.
B. Acceptance of alternates shall include provisions necessary to alter, adjust or otherwise modify work affected by the alteration.
C. Shop drawings shall include alternate work and shall reflect changes necessitated to other work.

1.14 GUARANTEE

A. Electrical work shall be guaranteed for both materials and labor for a period of one year.
B. On-the-premises maintenance shall be provided at no cost to the purchaser for one year from the date of an operational and accepted installation unless damage is caused by misuse or abuse.
C. Guarantee all wiring and equipment to be free from inherent and mechanical defects due to workmanship and materials used for the period of one full year from date of operational and accepted installation. Replacement of all or part of the equipment and/or correction of such defects, including labor, shall be rendered without cost to the Owner with the guarantee period.
D. Manufacturer's equipment guarantees or warranties for periods of more than one year shall be included in the Operation and Maintenance Data.

1.15 WARRANTY

A. Warranty period shall be one year after final acceptance and payment of the system. Repairs or replacements made under the warranty shall bear an additional 1-year warranty dated from final acceptance of the repair or replacement. The Owner shall receive the benefit of all warranties furnished by manufacturers.

1.16 PROJECT/SITE CONDITIONS

A. Carefully examine the contract documents, visit the site, and thoroughly become familiar with the local conditions relating to the work prior to bidding. Failure to do so will not relieve the contractor of the obligations of the Contract.
B. Install Work in locations shown on Drawings, unless prevented by Project conditions.
C. Prepare drawings showing proposed rearrangement of Work to meet Project conditions, including changes to Work specified in other Sections. Obtain permission of Architect/Engineer before proceeding.

1.17 CONTRACTOR’S RESPONSIBILITY TO VERIFY EQUIPMENT DIMENSIONS

A. The drawings, schedules and specifications have been prepared using one manufacturer for each piece of equipment as the basis for dimensional design. If the Contractor purchases equipment listed as a specified Acceptable Manufacturer but is not the scheduled manufacturer used for the base design, the Contractor shall be responsible for checking all the dimensions of the equipment to verify that it will fit in the space shown on the Drawings. Minor deviations in dimensions will be permitted, provided the ratings meet what was shown on the drawings and equipment will physically fit into the space allocated with suitable access around equipment for operation and maintenance on the equipment.
B. Contractor and/or manufacturer shall verify that the capacity and duty specified meets the characteristics of the equipment he submits for review.
C. If equipment is submitted for review and does not meet the physical size or arrangement of what was scheduled and specified, Contractor shall pay for all alternations required to accommodate such equipment at no additional cost to the Owner. Contractor shall also pay all costs for additional work required by other Contractors, Owner, Architect or Engineer to make changes which would allow the equipment to fit in the space.

1.18 CONTRACTOR’S RESPONSIBILITY TO VERIFY EXISTING CONDITIONS AND OPENINGS

A. Contractor shall field verify the size of existing openings, windows, doors, corridors, rooms, etc. for access of the new equipment into the existing building. If openings are too small for access, then Contractor shall provide new or enlarged openings, at his own expense, to facilitate entrance into existing space or building. Contractor may elect to order the equipment disassembled and/or with split housing for entrance into the existing space or building. Contractor shall reassemble equipment after it is in the space at his own expense.

PART 2 – PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Proposal shall be based upon the furnishing of all materials and equipment as specified, which in every case shall be new and, where not specifically referred to by manufacturer's name, of the best grade and quality available.
B. Equipment and material shall be without blemish or defect and shall not be used for temporary light or power purposes, including lamps, without the Architect/ Engineer's written authorization.
C. Items of equipment of one generic type (such as fuses), except conduit, conduit fittings, outlet boxes, wiring and cable, shall be the product of one manufacturer throughout, unless otherwise indicated or accepted by the Architect/Engineer.
D. Where two or more makes or kinds of materials or equipment are specified, indicate which of these choices will be used. This information shall be included with the list of manufacturers for equipment and materials to be submitted to the Architect/Engineer.
E. Manufacturers of equipment shall be firms regularly engaged in manufacturing factory-fabricated systems and equipment whose products have been in satisfactory use in similar service for not less than 5 years.

2.2 MANUFACTURERS NAMEPLATES

A. Each major electrical component such as switchgear, transformers, motor control centers, panelboards, circuit breakers, disconnect switches, etc. shall have the manufacturer's name, address, catalog number, model number, rating, and any other required specified markings on a plate or label located inside the cover or otherwise inconspicuously but readily accessible.

PART 3 – EXECUTION

3.1 DELIVERY AND STORAGE

A. Receive, handle, and store electrical items and materials at the project site. Materials and electrical items shall be so placed that they are protected from damage and deterioration.
B. Existing equipment which is to be reused shall be cleaned and protected against damage. Equipment which is removed and stored for reuse shall be stacked, boxed or crated in such a manner as to prevent damage. The cost to repair/replace this equipment due to damage incurred during its removal, storage or reinstallation shall be borne by the Contractor.
C. The Contractor shall bear full responsibility for equipment judged unacceptable due to his failure to comply with these specifications.

3.2 INSTALLATION

A. The Drawings for work under Division 16 are diagrammatic and are intended to convey the scope of work and indicate the general arrangement of conduit, boxes, equipment, fixtures and other work included in the Contract.
B. Location of items required by the Drawings or specifications not definitely fixed by dimensions are approximate only and exact locations necessary to secure the best conditions and results shall be determined at the site and shall be subject to the approval of the Architect/Engineer.
C. Follow Drawings in laying out work, check drawings of other trades to verify spaces in which work will be installed and maintain maximum headroom and space conditions at all points.
    1. Where headroom or space conditions appear inadequate, the Architect/Engineer shall be notified before proceeding with installation.
    2. Minor conduit rerouting and changes shall be made at no additional cost to the Owner.
D. Perform all work with skilled mechanics of the particular trade involved in a neat and workmanlike manner.
E. Perform all work in cooperation with other trades and schedule.
F. Perform all work in accordance with the manufacturer's recommendations.
G. Furnish other trades advance information on locations and sizes of frames, boxes, sleeves and openings needed for the work, and also furnish information and shop drawings necessary to permit trades affected to install their work properly and without delay.

H. Where there is evidence that work of one trade will interfere with the work of other trades, all trades shall assist in working out space allocations to make satisfactory adjustments and shall be prepared to submit and revise coordinated shop drawings.
I. With the approval of the Architect/Engineer and without additional cost to the Owner, make minor modifications in the work as required by structural interferences, by interferences with work of other trades or for proper execution of the work.
J. Work installed before coordinating with other trades so as to cause interference with the work of such other trades shall be changed to correct such condition without additional cost to the Owner and as directed by the Architect/Engineer.
K. Architect/Engineer reserves the right to change location of electrical equipment or device within 10’-0” radius before work is installed without extra charge.
L. Electrical Contractor shall cooperate with other trades and coordinate work so that conflicts with other work are eliminated.
M. Equipment shall be installed with adequate space allowed for removal, repair or changes to equipment. Ready accessibility to removable parts of equipment and to wiring shall be provided without moving other equipment which is to be installed or which is in place. Electrical Contractor shall verify measurements. Discrepancies shall be brought to the Architect/Engineer's attention for interpretation.
N. Determine temporary openings in the buildings that will be required for the admission of apparatus furnished under this Division and notify the Architect/Engineer accordingly. In the event of failure to give sufficient notice in time to arrange for these openings during construction, assume all costs of providing such openings thereafter.
O. Location of electrical outlets, lighting fixture, lighting panels, cabinets, equipment, etc. is approximate and exact locations shall be determined at the project.
P. Electrical Contractor shall refer to contract documents for details, reflected ceiling plans, and large-scale drawings.
Q. Apparatus, lighting fixtures, material or work not shown on the drawings, but mentioned in the project specifications, or vice versa or any included accessories such as wiring, relays, switches, transformers (line voltage or low voltage), etc., necessary to make the work complete and ready for operating, even though not specified or shown on the electrical drawings shall be furnished and installed without additional expenses to the Owner. It is the Contractor’s responsibility prior to bids to review all project documents.
R. Verify final locations for rough-ins with field measurements of the actual equipment to be connected. Refer to equipment specifications in Division 1 through 16 for rough-in requirements.
S. Equipment specified under other divisions and requiring electrical supply shall be erected, aligned, leveled and prepared for operation. Provide required controls and accessories along with installation instructions, diagrams, dimensions and supervision of installation and start-up. Provide the required electrical rough-ins and connections and confirm the electrical controls and accessories furnished under the specifications for the other divisions. Install those controls and accessories not located in the mechanical piping and ductwork. Provide additional electrical controls, accessories, fittings and devices not specified under the equipment but required for a finished, operating job. Make all final electrical connections. Participate in the start-up and test procedure.
T. Where surface mounted conduit or surface mounted raceway is installed on new or existing walls, the electrical contractor shall paint the surface mounted conduit or surface mounted raceway to match the new or existing wall.
U. Electrical Contractor shall weatherproof all openings and penetrations through foundations and exterior walls created by fixtures and conduits to prevent moisture from entering through.
V. Contractor shall furnish other trades advance information and/or shop drawings on locations and sizes of conduits, raceways, equipment, frames, boxes, sleeves and openings, etc. needed for their work to install their work properly and without delay.

W. Contractor shall provide sleeves in beams, floors, columns and walls as shown on the drawings, as required by job site conditions, and/or as specified, when installing their work. All beams and columns which are required to be sleeved shall be cut and reinforced as required by field conditions and locations and sizes shall be checked and approved by Architect before contractor cuts any structural building member.

X. Contractor shall refer to the architectural and structural contract drawings (before submitting their bids) to familiarize themselves with the extent of the general contractor's work, ceiling heights and clearance for installing their work.

Y. Contractor shall install all auxiliary supporting steel as required for the supporting of their conduit, fixtures, devices, equipment, etc. All supporting steel for items above a suspended ceiling shall be from new building structure members only. All supports in the existing building shall be from walls. No connection to wood, roof deck or structure is allowed.

Z. The locations shown for all lighting fixtures and ceiling mounted electrical equipment are diagrammatic. Exact location shall be determined from the reflected ceiling plans and/or on the job site by the construction manager. It shall be the contractor's responsibility to maintain code required spacing for items such as fire alarm devices.

AA. Contractor shall be required to maintain the fire rated integrity of floors and/or wall partitions. All penetrations through fire rated building elements shall be effectively sealed using approved materials and methods.

BB. Unless indicated otherwise, the Architect/Engineer makes no representation as to whether or not any hazardous or contaminated materials (including but not limited to asbestos, PCB's, contaminated soils, etc.) are present within the existing building or on the site. Work shown on the drawings and/or indicated in the specifications shall not be construed to call for contact with any of these materials. If these materials are encountered or suspected, the contractor shall not disturb them and shall contact the architect/engineer immediately.

CC. Contractor shall store all materials and equipment shipped to the site on a protected area. If material is stored outside the building, it must be stored off the ground a minimum of six inches (6") set on 6 x 6 planks and/or wood pallets. All material and equipment must be completely covered with waterproof tarps or visqueen. All conduit will have the ends closed to keep out dirt and other debris. No equipment will be allowed to be stored on the site unless it is sitting on wood planks and completely protected with weatherproof covers.

DD. This contractor shall be responsible for furnishing all labor and material required to patch all openings in existing floors, walls, ceilings and fire separations created by the removal of this trades material and equipment where these openings are not to be reused.

3.3 PROTECTION

A. Protect conduit and wireway openings against the entrance of foreign matter by means of plugs or caps. Cover fixtures, materials, equipment and devices or otherwise protect against damage from any cause, both before and after installation. Fixtures, materials, equipment, or device damaged prior to final acceptance of the work shall be restored to their original condition or replaced, all at no additional cost to Owner.

B. Equipment shall be inherently safe and moving parts shall be covered with guards.

3.4 COOPERATION

A. Where jurisdictional rules require the assistance of electrical mechanics in the moving and setting of electrically power equipment, provide such assistance.

B. Where work covered by this section connects to equipment furnished under other sections, verify electrical work involved in the field and make proper connection to such equipment.

3.5 CUTTING AND PATCHING

A. Do drilling, cutting, fitting and patching necessary for the installation of conduits, wireways, and other electrical equipment, and provide supports necessary for same and for bracing and anchorage of work. No cutting of structural work or of fireproofing shall be done without the written consent of the Architect/Engineer.
B. Conduits passing through roofs or other surfaces exposed to weather shall be properly flashed as specified in roofing and waterproofing sections. This flashing work shall be paid for as part of the electrical work.

3.6 WALL CHASES

A. Provide templates or details of wall chases, where conduits, pull boxes, cabinets, and other items of equipment are to be concealed or recessed, before the work of other trades is performed in the respective areas. Show exact locations and sizes of such equipment.

3.7 SLEEVES AND OPENINGS

A. Provide sleeves and openings for exposed wires, cables, and wireways where they pass through walls and floors.
B. Sleeves for individual cables shall be hot-dip galvanized inside and outside. Sleeve shall be equal in gauge to heavy wall steel conduit and extended 3 inches above finished surface or wall.
C. Furnish complete dimensioned drawings of openings required through walls and floors, for conduits, or busways, or wireways, before the work of other sections is performed in the respective areas.
D. Installation of 3-inch-high concrete curbs around openings through concrete slabs in electrical closets and other openings, shall be provided under Division 3.
E. Pack or fill sleeves and openings after the completed work is in place. Filling shall comply with U.L., match rating of original construction and shall provide a waterproof and fireproof packing to prevent leakage of liquid, smoke, or fire through the sleeve or opening.

3.8 EQUIPMENT NOISE LIMITATION

A. Noise levels of electrical devices and equipment shall be within acceptable limits as established by NEMA or other valid noise rating agencies. Noise levels shall be subject to the Architect/Engineer’s acceptance, based on practical and reasonable consideration of occupancy requirements.
B. Check and tighten the fastenings of sheet metal plates, covers, doors, and trims to prevent vibration isolation and chatter under normal conditions of use.
C. When located elsewhere than in high-noise-level equipment rooms, the enclosures of solenoid-operated switching devices and other noise-producing device shall have anti-vibration mountings and non-combustible sound-absorbing linings.
D. Reactors, dimmers, lamp ballasts, and solenoids shall be designed and rated for “quiet” operation.
E. Remove and replace any individual electrical item or device that is found to produce a sound energy output exceeding that of other identical devices installed at the project.

3.9 EXCAVATING AND BACKFILLING

A. Excavating, bracing and shoring, testing disposition of excess, excavated material, provision of borrow, and placing of backfill shall be in accordance with Division 33 Utilities Excavating and Backfilling.

3.10 TEMPORARY UTILITIES AND HEAT

A. Contractor’s attention is directed to Division 01, which sets forth respective responsibilities of all concerned with furnishings temporary water, electricity and heat for use during construction of all Project.

3.11 EXECUTION, CORRELATION AND INTENT OF DOCUMENTS

A. In the event that conflicts, if any, cannot be settled promptly and amicably between the affected trades, with work proceeding in a workmanlike manner, then the Architect/Engineer shall decide which work is to be relocated and his judgment shall be final and binding on this Contractor.

3.12 ADJUSTMENTS

A. The primary adjustments of the system(s) shall be accomplished by the Contractor to the complete satisfaction of the Owner and Architect/Engineer at the time of completion of the installation.

3.13 ACCESS PANELS

A. Provide access panels as required. The access panels shall comply with Division 8.

3.14 TESTING

A. General: Furnish meters, instruments, cable connections, equipment or apparatus necessary for making all tests.

B. Insulation Tests:

1. After being pulled in place and before being connected, test all service and feeder cables with 1000-volt, 60 Hz insulation tester for one minute to determine that conductor insulation resistance to ground is not less than that recommended by the manufacturer. Test all branch circuit conductors for lighting, receptacle and miscellaneous loads prior to connection of loads. Tests shall not register less than one megaohm to ground during an insulation test as described above for service and feeder cables. Remove, replace and retest all cable failing insulation test.
2. Measure insulation resistance of electrical wiring with a self-contained instrument such as direct-indicating ohmmeter of the generator battery of electronic type.
3. When using any type of d-c voltage source, it is essential that the output voltage is steady to prevent fluctuations in charging current. Where protective resistors are used in test instruments, take into account their effect on the magnitude of the voltage applied to the insulation under test. Properly maintain the instrument used in insulation resistant testing. Make periodic checks to ensure that rated voltage is delivered and that the instrument is in calibration.
4. Unless otherwise specified, the insulation resistance shall be approximately one megaohm for each 1000-volts of operating voltage with a minimum value of one megaohm.

C. Test all motors under load, with ammeter readings taken in each phase and the RPM of motors recorded at the time. Test all motors for correct direction of rotation.

D. Documentation: Keep records of all tests, in tabulated, permanent, reproducible form, completely indexed and explained, indicating the specific test performed, environmental conditions such as temperature and humidity, date of performance, results obtained, corrective actions taken (if any), final results, and comments, if required. Copies of all tests shall be delivered to the Architect/Engineer prior to this final project review.

3.15 MOUNTING HEIGHTS

A. Mounting heights of electrical items shall be as listed below, unless otherwise specified, or by the Architect/Engineer's field instructions. Dimensions are above finished floor, unless otherwise indicated. - In areas where codes require different mounting heights, as in hazardous areas, comply with code requirements.

1.	General Receptacles	- 18" to C.L.
2.	Outdoor Receptacles	- 24" to C.L.
3.	General Tele and Data Outlets	- 18" to C.L.
4.	General Toggle Switches	- 46" to C.L.
5.	Fire Alarm Pull Stations	- 46" to C.L.
6.	Security and Intercom Call Stations	- 46" to C.L.
7.	Clock and Paging Speaker Outlets	- 84" to C.L.
8.	Fire Alarm Audio/Visual Devices	- 82" to C.L.
9.	Corridor Wall Sconces (>4" deep)	- 66" to C.L.
10.	Exit Signs	- 90" to C.L.
11	Volume Controls	46" to C.L.
12.	T.V. Outlets	82" to C.L.
13.	Individual Disconnects and Starters	- 60" to C.L.
14.	Grouped Disconnects and Starters	> 12" to C.L. < 72" to C.L.
15.	Panelboard Overcurrent Devices	> 12" to C.L. < 72" to C.L.
16.	Grouped Utility Revenue Meters	> 30" to C.L. < 66" to C.L.

END OF SECTION

SECTION 16060

ELECTRICAL DEMOLITION FOR REMODELING

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. The General Provisions and Supplementary Conditions of the Contract of the General Requirement Specifications, apply to the work in this Section.
B. This Section is hereby made a part of all other sections of Division 16 as fully as if repeated in each therein.

1.2 SECTION INCLUDES

A. Electrical demolition: The work specified in this section includes providing labor, material, equipment, and services necessary for electrical demolition as shown on the drawings and as herein specified to accommodate new construction. The project includes demolition, relocation and replacement of existing electrical equipment, feeders, branch wiring, signal cables, etc. with new work. Contractor shall remove, reinstall, or relocate that portion of the existing equipment, system, wiring, fixtures and drawings which are a part of or which applies to the electrical trade.
B. Selective demolition including:
    1. Non-destructive removal of materials and equipment for reuse or salvage as indicated.
    2. Dismantling electrical materials and equipment made obsolete by these installations.

1.3 RELATED SECTIONS

A. Section 16010 – Basic Electrical Provisions.

1.4 REQUIREMENTS

A. Contractor shall provide caution and warning signs at all hazardous areas and at all door entries to construction rooms and areas during the entire construction period per IEPA law and regulations.

1.5 SEQUENCING

A. Sequence the Work in the following order:
    1. Complete new or temporary system as specified.
    2. Cut-over to new or temporary system.
        a. Schedule with Owner at least one week in advance.
    3. Remove items specified.

1.6 SCHEDULING

A. Schedule work to coincide with other trades and project schedule.
B. Cease operations immediately when structure appears to be in danger and notify Architect/ Engineer. Do not resume operations until directed.

1.7 COORDINATION

A. Conduct demolition to minimize interference with adjacent and occupied building areas.
B. Coordinate demolition work with the construction manager and other related trades.
C. Coordinate and sequence demolition so as not to cause shutdown of operation of surrounding areas.
D. Shut-down periods:
    1. Arrange timing of shut-down periods of system, service with Owner. Do not shut down any service, without prior written approval.
    2. Keep shut-down period to minimum or use intermittent period as directed by the Owner.
    3. Maintain life-safety system in full operation in occupied facilities or provide notice minimum 15 working days in advance.

1.8 MAINTAIN CONTINUITY OF SERVICE

A. Any downtime time period shall be at the convenience of the Owner and approved by the General Contractor. Contractor shall give a minimum of 15 working days prior written notice to the General Contractor in advance of any desired shutdown. Prior written notice shall include a schedule for downtime, work to be performed. All downtime period shall be on weekends or off hours with exact time period approved in advance in writing by the General Contractor. Coordinate an overall schedule that is to be submitted and approved by the General Contractor.
B. An electrician shall be on the premises when any trade is working in close proximity to live equipment or within electric rooms during renovation by any trade.
C. All premium time, overtime, labor, material and equipment costs required to accomplish the above shall be included in the Contractor's bid proposal.

1.9 PROTECTION

A. Perform removal of equipment and related components, in such manner as to eliminate hazards to persons and property; to minimize interference with use of adjacent areas, utilities and structures or interruption of use of such utilities; and to provide free passage to and from such adjacent areas of structures.
B. Provide safeguards, including warning signs, barricades, temporary fences, warning lights, and other similar items that are required for protection of all personnel during demolition and removal operations.

PART 2 – PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Materials and equipment for patching and extending work: As specified in individual Sections.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Verify field measurements and circuiting arrangements.
B. Verify that abandoned wiring and equipment serve only abandoned facilities.
C. Demolition Drawings are based on casual field observation and existing record documents. Contractor may purchase a copy of existing record documents for reference during bidding or construction. Report discrepancies to Architect/Engineer before disturbing existing installation. Verify existing conditions before performing any work.
D. Beginning of demolition means installer accepts existing conditions.
E. Where work is concealed above ceiling spaces which are to be removed, cut opening in ceiling and examine condition above the ceiling. If work requires certain devices to remain and the ceiling is supporting the device, contractor shall support device adequately from floor slab above, prior to ceiling demolition or at his option, remove the device and reinstall completely.
F. Contractor shall verify existing circuit feeding each receptacle in demolition and remodeled area and document in the panelboard directory on record drawings. Contractor shall identify to Architect/ Engineer any wiring in poor condition or overload condition which exists.

3.2 PREPARATION

A. Disconnect electrical systems in walls, floors, and ceilings scheduled for removal.
B. Provide temporary wiring and connections to maintain existing systems in service during construction. When work must be performed on energized equipment or circuits, use personnel experienced in such operations.

C. Existing Electrical Service: Maintain existing system in service until new system is ready for installation. Obtain permission from Owner at least 15 working days before completely disabling system. If outage lasts more than 24 hours, Contractor shall provide and install a generator for temporary service. Temporary service shall be provided until new service is in operation. Refer to Division 1 for temporary power. Make temporary connections to maintain service in areas adjacent to work area while switchovers are completed.
D. Existing Fire Alarm System: Maintain existing system in service until new system is accepted. Disable system only to make switchovers and connections. Notify Owner and local fire service at least 24 hours before partially or completely disabling system. Minimize outage duration. - Make connections to maintain service in existing areas not to be remodeled.
E. Existing central intercom/speaker systems: Maintain existing system in service until new or upgraded systems are accepted. Disable system only to make switchover and connections. Notify Owner at least 24 hours before partially or completely disabling systems. Minimize outage durations. Make temporary connections to maintain service in areas adjacent to work area.
F. Existing Clock/Bell System: Maintain existing system in service. Disable system only to make switchovers and connections. Notify Owner and Architect/Engineer at least 24 hours before partially or completely disabling system. Minimize outage duration. Make connection to maintain service in existing areas not to be remodeled.
G. Existing Security/Camera System: Maintain existing system in service. Disable system only to make switchovers and connections. Notify Owner and Architect/Engineer at least 24 hours before partially or completely disabling system. Minimize outage duration. Make connection to maintain service in areas not to be remodeled.
H. Coordinate utility service outages with Utility Company.
I. Existing Suspended Ceiling System: Disconnect and remove light fixtures, fire alarm devices, speakers and conduit, etc. to facilitate demolition work.
J. Protect adjacent materials that are to remain. Install and maintain dust and noise barriers to keep dirt, dust and noise from being transmitted to adjacent areas. Remove protection and barriers after demolition operations are complete.
K. Locate, identify, and protect electrical services passing through demolition areas and serving other areas outside the demolition limits. Maintain services to areas outside demolition lines. When services must be interrupted or relocated, install temporary and/or permanent services for affected areas. Services originating within demolition limits and serving areas outside demolition limits shall be maintained.

3.3 DEMOLITION AND EXTENSION OF EXISTING ELECTRICAL WORK

A. Demolish and extend existing electrical work under provisions of the General Requirement Specification Sections and this Section.
B. Remove, relocate, and extend existing installations to accommodate new construction.
C. Remove abandoned wiring to source of supply.
D. Remove exposed abandoned conduit, including abandoned conduit above accessible ceiling finishes to source of supply. Cut concealed conduit flush with walls and floors, and patch surfaces. Remove conduit within walls to be removed. Provide cap on abandoned conduits on each end. If the existing concealed conduits are in conflict with new work remove them.
E. Disconnect abandoned outlets and remove devices. Remove abandoned outlets if conduit servicing them is abandoned and removed. Provide blank cover for abandoned outlets which are not removed.
F. Disconnect and remove electrical devices and equipment serving utilization equipment that has been removed.
G. Disconnect and remove abandoned luminaires. Remove brackets, stems, hangers, and other accessories.
H. Disconnect and remove abandoned panelboard and distribution equipment.
I. Maintain access to existing electrical installations which remain active. Modify installation or provide access panel as appropriate.

J. Extend existing installations and provide alterations using acceptable materials and methods compatible with existing electrical installations and in accordance with the equipment manufacturers recommendations.
K. Remove, demount, and disconnect existing electrical materials and equipment indicated to be moved and salvaged, and deliver materials and equipment to the location designated for storage. Salvaged material shall be stacked, boxed or crated in such a manner as to prevent damage.
L. Any existing circuits or equipment not shown on drawings and which are logically expected to be continued in service and which may be interrupted or disturbed during construction shall be reconnected in an approved manner. Check and maintain continuity for all existing devices/equipment to remain. In addition, any existing circuits or equipment which may require relocation or rerouting as a result of the work of this project shall be done by this Contractor with no additional compensation. Provide blank cover plates on empty outlets which are to remain.
M. Provide new lighting switch(es) so each lighting area affected by new work shall be controlled locally.
N. Provide code required disconnects to existing and relocated, equipment when affected by new work.
O. Where existing equipment, devices and fixtures are to remain but are affected by new work such as replacement of ductwork and piping, reconditioning of walls, ceilings, roofs and floors of re-laminating of counters, cabinets and casework, disconnect these items and add extension rings, clean and reinstall same in line with new walls, ceilings and surfaces. Note that certain work (such as replacement of piping, ductwork, etc.) may be outside the limit to direct renovation. Electrical contractor shall review drawings of other trades for such work and incorporate that in his scope of work. Provide all necessary materials and labor and rewire in accordance with present code requirements.
P. Owner shall have the option of selecting any or all of the items, including copper wiring, which are designated to be removed by the contractor as salvage for the Owner. Contractor shall remove such items with extreme care and return such items to the Owner. Any equipment which the Owner does not want will become the property of the contractor and promptly removed from the site.
Q. All cutting and patching, relocating of any equipment, lighting fixtures, conduit, piping, etc., necessary for any work under this contract will be by the respective contractors unless noted otherwise in the architectural sections.
R. Reference shall be given to Owner to keep any removed device, fixture or equipment. If Owner does not want to keep any of them, dispose them as required.
S. Ballasts manufactured prior to 1980 containing PCB’s and lamps containing mercury shall be disposed of by a federal or state E.P.A. approved method and in accordance with specifications.
T. HID and fluorescent lamps containing mercury shall be disposed of by a federal or state E.P.A. approved method and in accordance with specifications.
U. Before disconnecting, verify with Owner removal or relocation of all existing devices/equipment. No additional cost will be permitted for lack of such verification.
V. All existing outlet, junction boxes, conduit and wire which is supported by the existing ceiling system will be re-supported to the building construction. New wiring and outlets will be supported from the building construction.
W. This contractor shall coordinate all his work with the other contractors at the job site before removing existing electrical and installing new items.
X. Equipment removal in certain locations may require the installation of a junction box to reconnect circuits that remain in operation. Extend conduit and wiring as required to maintain power to remaining equipment.
Y. It is the intent of the electrical demolition drawing(s) to indicate areas in which electrical equipment, conduit, lighting fixtures, devices, etc. are to be removed to allow for the renovation phase of construction. The electrical demolition plan is for reference purposes only and it is not intended to be the sole source of existing conditions.

Z. Electrical Contractor shall be responsible for his own clean-up throughout the course of the demolition work. In the event he fails to provide such clean-up the Architect/Engineer will direct the clean-up to be performed by another contractor and the electrical contractor will be back-charged as deemed appropriate by Architect/Engineer.

AA. The contractor performing the demolition work, shall remove no more than 8” of building material around each device being demolished.

BB. Disconnect all electrical connections to mechanical, plumbing and architectural equipment for removal by others. Remove all starters, disconnect switches and related conduit and wiring serving such equipment which is indicated to be removed. Refer to mechanical, plumbing and architectural drawings for exact requirements.

CC. It shall be the contractors option to reuse existing concealed conduit and flush mounted backboxes where applicable. If existing conduit and/or backboxes are utilized it shall be the electrical contractor’s responsibility to provide additional supports and fittings required to conform to the specification.

DD. Remove all exposed abandoned and exposed non-required conduits together with their associated wires. Remove inaccessible conduits together with all their wires if they are in conflict with renovation work.

3.4 CLEANING AND REPAIR

A. Clean and repair existing materials and equipment which remain or are to be reused.

B. Panelboards: Clean exposed surfaces and check tightness of electrical connections. Replace damaged circuit breakers and provide closure plates for vacant positions. Provide typed circuit directory showing revised, existing circuiting arrangement and room numbers served.

C. Luminaires: Remove existing luminaires for cleaning. Use mild detergent to clean all exterior and interior surfaces; rinse with clean water and wipe dry. Replace lamps, ballasts, and broken electrical parts.

D. Cabinets and Cover Plates: Where existing cabinets and cover plates are to be used for installation of new panelboard interiors, contractor shall clean exposed surfaces and paint area near cabinet and cover plates, removed from panelboard, to match existing condition. Contractor shall replace cabinet or coverplate if necessary to accommodate new work.

3.5 FLOOR AND WALL OPENINGS

A. Opening through floors and walls where piping or equipment has been removed shall be sealed to maintain any fire ratings and to seal off cold, smoke and toxic fumes. Use appropriate sealing materials and methods to maintain existing rating of the floor and wall.

3.6 DAMAGE TO OTHER WORK

A. The Contractor shall be held responsible for any damage caused to existing installations not pertinent to the Contract. The cost of repairs to such damaged work shall be charged against the Contractor.

3.7 CLEAN-UP

A. On completion of work of this section and after removal of all debris, site shall be left in clean condition satisfactory to the Construction Manager. Clean-up shall include off the premises disposal of all items and materials not required to remain the property of the Contractor as well as all debris and rubbish resulting from demolition operations.

B. Debris, including brick, asphalt, concrete, stone and similar materials shall become property of Contractor and shall be disposed of by the Contractor, off the property. Remove concrete foundations, conduits, anchor bolts, and all appurtenances.

3.8 INSTALLATION

A. Install relocated materials and equipment under the provisions of the General Requirement Specification Sections.

END OF SECTION

SECTION 16111

CONDUIT

PART 1 – GENERAL

1.1 RELATED DOCUMENTS
A. The General Provisions of the Contract, including Conditions of the Contract and the General Requirement Specification Sections, apply to the work in this Section.
B. This Section is hereby made a part of all other sections of Division 16 as fully as if repeated in each therein.

1.2 SECTION INCLUDES
A. Metal conduit.
B. Flexible metal conduit.
C. Liquidtight flexible metal conduit.
D. Electrical metallic tubing.
E. Nonmetal conduit.
F. Fittings and conduit bodies.

1.3 RELATED SECTIONS
A. Section 16130 - Boxes.
B. Section 16170 - Grounding and Bonding.
C. Section 16190 - Supporting Devices.
D. Section 16195 - Electrical Identification.

1.4 REFERENCES
A. ANSI C80.1 - Rigid Steel Conduit, Zinc Coated.
B. ANSI C80.3 - Electrical Metallic Tubing, Zinc Coated.
C. ANSI/NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies.
D. Local Electrical Code.
E. NECA "Standard of Installation."
F. NEMA RN 1 - Polyvinyl Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit and Intermediate Metal Conduit.
G. NEMA TC 3 - PVC Fittings for Use with Rigid PVC Conduit and Tubing.

1.5 SUBMITTALS
A. Submit under provisions of the General Requirement Specification Sections and Section 16010.
B. Product Data: Provide for metallic conduit, flexible metal conduit, liquid-tight flexible metal conduit, metallic tubing, nonmetallic conduit, fittings, and conduit bodies.
C. Project Record Documents: Accurately record actual routing of conduits 1 1/4 inches and larger.

1.6 QUALIFICATIONS
A. Manufacturer: Company specializing in manufacturing Products specified in this Section with minimum three years' experience.

1.7 REGULATORY REQUIREMENTS
A. Conform to requirements of local electrical code.
B. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for the purpose specified and indicated.

1.8 COORDINATION
A. Coordinate under provisions of the General Requirement Specification Sections and Section 260500.
B. Design Requirements: Conduit Size per local electrical code.
C. Field Measurements: Verify that field measurements are as shown on Drawings.
D. Field Locations: Verify routing and termination locations of conduit prior to rough in.

E. Where conduit routing is shown on Drawings, it is in approximate locations unless dimensioned. Include conduit lengths within 10 ft of length where shown.
F. Where conduit destination is indicated and routing is not shown on Drawings, determine exact routing and lengths required.

1.9 DELIVERY, STORAGE, PROTECTION, AND HANDLING

A. Accept Products and inspect for damage.
B. Protect conduit from corrosion and entrance of debris by storing above grade. Provide appropriate covering.
C. Protect PVC conduit from sunlight.
D. Conduit that shows corrosion within the guarantee period shall be replaced.

PART 2 – PRODUCTS

2.1 CONDUIT SCHEDULE

A.

Conduit Location	From V up thru 50V -	Above 50V up thru 250V -	Above 250V up thru 600V - -
Above an Accessible Ceiling	≤ 2 1/2"EMT ≥ 3" IMC	≤ 2 1/2" EMT ≥ 3" IMC	≤ 2 1/2" EMT ≥ 3" IMC
Concealed in Walls	≤ 2 1/2"EMT ≥ 3" IMC	≤ 2 1/2"EMT ≥ 3" IMC	≤ 2 1/2"EMT ≥ 3" IMC
Exposed Interior	≤ 2 1/2"EMT ≥ 3" IMC	≤ 2 1/2" EMT ≥ 3" IMC	≤ 2 1/2" EMT ≥ 3" IMC
Below Slab	IMC/PVC	IMC/PVC	IMC/PVC
Hazardous Areas	IMC	IMC	HWG
Exposed Exterior	HWG	HWG	HWG
Below Grade	HWG/PVC	HWG/PVC	HWG/PVC
Corrosive Environments		HWG – PVC Coated	HWG – PVC Coated

* All voltages are line-to-line or line-to-neutral.

2.2 CONDUIT REQUIREMENTS

A. Minimum Size: ¾-inch. All remaining conduits shall be minimum of ¾-inch including conduits for telephone, data, any other control, intercom device, etc.
B. Conduit installed below grade at exterior locations may be Schedule 40 PVC when encased within a 3-inch concrete enclosure.
C. Flexible conduit connections to recessed lighting fixtures shall be made with UL approved flexible steel conduit, except where UL listed liquid tight flexible conduit is required by code, such as in air plenums, etc.
D. Final connections to motors shall be made through UL listed liquid tight flexible steel conduits, ½-inch minimum size unless otherwise indicated.
E. Flexible connections, where required, shall be made with flexible metallic tubing ¾-inch minimum size or sized in accordance with code, except in areas where such connections will be exposed to oil, grease, water, or where installed out of doors. In those areas of adverse exposure, flexible connections shall be made with UL listed liquid tight flexible steel conduit. Grounding conductors with green colored insulation shall be extended through all flexible connections including fixture "whips" and fastened to terminals within the first junction boxes on either side of the flexible length. Refer to Section 16510 for flexible connections to lighting fixtures

2.3 METAL CONDUIT

A. Manufacturers:
   1. Allied.
   2. LTV/Republic.
   3. Steelduct.
   4. Wheatland.
B. Rigid Steel Conduit: ANSI C80.1; hot dipped galvanized or electro-galvanized steel.
C. Intermediate Metal Conduit (IMC): Rigid steel.
D. Fittings and Conduit Bodies: ANSI/NEMA FB 1; all steel fittings of threaded joints.

2.4 FLEXIBLE METAL CONDUIT

A. Description: Interlocked galvanized steel construction.
B. Fittings: ANSI/NEMA FB 1; steel or malleable iron.
C. Minimum Size: ½-inch (13 mm), unless otherwise specified.
D. Flexible metal conduit shall only be used as a final connection to equipment and shall not exceed 72” in total length. Extending flexible runs beyond 72” by adding a junction box or small run of conduit is not allowed.

2.5 LIQUIDTIGHT FLEXIBLE METAL CONDUIT

A. Manufacturers:
   1. Anaconda.
   2. American Brass.
   3. Electri-Flex Company.
B. Description: Interlocked galvanized steel construction with UL PVC jacket.
C. Fittings: ANSI/NEMA FB 1; steel or malleable iron.
D. Liquid tight flexible metal conduit shall be used for final connection to the following equipment;
   1. Pumps
   2. Boilers
   3. Chillers
   4. Air Supply Units
   5. Condensing Units
   6. Transformer
E. Liquid tight flexible metal conduit shall only be used as a final connection to equipment and shall not exceed 72” in total length. Extending flexible runs beyond 72” by adding a junction box or small run of conduit is not allowed.

2.6 ELECTRICAL METALLIC TUBING (EMT)

A. Manufacturers:
   1. Allied.
   2. LTV/Republic.
   3. Steelduct.
   4. Wheatland.

B. Description: ANSI C80.3; hot dipped or electro-galvanized tubing.

2.7 EMT FITTINGS AND CONDUIT BODIES

A. Manufacturers:
   1. Appleton.
   2. Crouse Hinds/Midwest.
   3. OZ/Gedney.
   4. Raco.
   5. Steel City.
   6. T&B

B. Description: ANSI/NEMA FB 1; steel or malleable iron, compression type with insulated throat.
   1. Set-screw type fittings are not acceptable.
   2. Die-cast fittings of pot metal are not acceptable.

2.8 NONMETALLIC CONDUIT

A. Manufacturers:
   1. Carlon.
   2. Sedco.

B. Description: NEMA TC 2; Schedule 40 PVC, type EB for concrete encasement.

C. Fittings and Conduit Bodies: NEMA TC 3; material to match conduit.

2.9 EXPANSION FITTINGS

A. Provide a suitable expansion fitting in each concealed or exposed electrical raceway crossing a building expansion joint. Fittings shall be complete with bonding jumper and clamps.

B. Manufacturers: OZ/Gedney, Crouse-Hinds and Appleton.

2.10 BUSHINGS

A. Bushings for conduits 1 inch and smaller shall be self-extinguishing thermoplastic grounding type – 150 degrees C. and insulating type.

B. Bushings for conduits 1¼-inch and larger shall be malleable iron body with 150-degree C. insulating ring and shall be grounding type. Insulating material shall be locked in place and non-removable.

2.11 CONDUIT SYSTEM FOR CORROSIVE ENVIRONMENTS

A. All PVC coated conduit, fittings, and accessories shall be supplied by the same manufacturer.

B. Acceptable Manufacturers:
   1. Plasti-Bond
   2. Perma-Cote
   3. KorKap

C. The PVC coated galvanized rigid steel conduit must be UL Listed. The PVC coating must have been investigated by UL as providing the primary corrosion protection for the rigid metal conduit. Ferrous fittings for general service locations must be UL Listed with PVC as the primary corrosion protection. Hazardous location fittings, prior to PVC coating must be UL listed. All PVC coated conduit, fittings, and accessories must be new, unused material. Applicable UL standards may include: UL 6 Standard for Safety, Rigid Metal Conduit, UL 514B Standard for Safety, Fittings for Conduit and Outlet Boxes.

D. The PVC coated galvanized rigid conduit must be ETL Verified to the Intertek ETL SEMKO High Temperature H2O PVC Coating Adhesion Test Procedure for 200 Hours. The PVC coated galvanized rigid conduit must bear the ETL Verified PVC-001 label to signify compliance to the adhesion performance standard.

E. The bond between the PVC coating and the conduit surface shall be greater than the tensile strength of the coating. This bond shall be verified by testing described in NEMA Standard RN-1, section 3.8.
F. The conduit shall be hot dip galvanized inside and out with hot galvanized threads.
G. A PVC sealing sleeve extending one pipe diameter or two inches, whichever is less, shall be formed at every female fitting opening, except unions. The inside sealing sleeve diameter shall be matched to the outside diameter of the conduit.
H. The PVC coating on the outside of conduit couplings shall be 40 mils in thickness and have a series of raised longitudinal ribs to protect the coating from tool damage during installation.
I. Form 8 condulets, ½" through 2" diameters, shall have a tongue-in-groove, V-Seal gasket to effectively seal against the elements. The design shall be equipped with a positive placement feature to ease and assure proper installation. Certified results confirming seal performance at 15 psig (positive) and 25 in. of mercury (vacuum) for 72 hours shall be available.
J. Form 8 condulets shall be supplied with plastic encapsulated stainless-steel cover screws.
K. A urethane coating shall be uniformly and consistently applied to the interior of all conduit and fittings. This internal coating shall be a nominal 2-mil thickness. Conduit or fittings having pinholes or areas with thin or no coating shall be unacceptable.
L. The PVC exterior and urethane interior coatings applied to the conduit shall afford sufficient flexibility to permit field bending without cracking or flaking at temperatures above 30˚F.
M. All factory cut threads on conduit, elbows, nipples, and fittings shall be protected by application of a urethane coating.
N. Right angle beam clamps and U bolts shall be specially formed and sized to snugly fit the outside diameter of the PVC coated conduit. All U bolts will be supplied with plastic encapsulated nuts that cover the exposed portions of the threads.

PART 3 – EXECUTION

3.1 INSTALLATION - CONDUIT

A. Install conduit in accordance with NECA "Standard of Installation."
B. Install nonmetallic conduit in accordance with manufacturer's instructions.
C. Installation of the PVC coated conduit system shall be performed in accordance with the manufacturer’s installation manual. To assure correct installation, the installer shall be certified by the PVC coated conduit manufacturer before the installation can begin.
D. Arrange conduit to maintain headroom and present neat appearance.
E. Route conduit parallel and perpendicular to walls.
F. Route conduit installed above accessible ceilings parallel and perpendicular to walls.
G. Route conduit in and under slab from point to point.
H. Do not cross conduits in slab.
I. Maintain adequate clearance, minimum of 12-inches, between conduit and piping.
J. Maintain 12-inch clearance between conduit and surfaces with temperatures exceeding 104 degrees F.
K. Cut conduit square using saw or pipecutter; de burr cut ends.
L. Install no more than equivalent of three 90-degree bends between boxes. Use conduit bodies to make sharp changes in direction, as around beams. Use hydraulic one-shot bender to fabricate bends in metal conduit larger than 2-inch size or provide factory elbows.
M. Provide suitable pull string in each empty conduit except sleeves and nipples.
N. Ground and bond conduit under provisions of Section 16170.
O. Identify conduit under provisions of Section 16195.
P. In general, conduits shall be run concealed. Where exposed conduit runs are shown or required, they shall be run parallel to building construction and shall be suitably supported at required intervals.
Q. Conduits run to and from cabinets shall be run neatly, in accurate manner, and shall emerge from the floors and ceilings at right angles thereto.

R. Conduit stub ups and stub downs shall be arranged in a neat and orderly manner and shall emerge at right angles to floors or ceilings.
S. In equipment spaces, such as fan rooms, plenums, etc., conduits and outlets may be exposed, but shall avoid interference with ventilating ducts, piping, etc.
T. Exposed conduit installed on or adjacent to ventilating ducts shall be installed after the ducts are in place and shall be run from ceiling or wall junction boxes in such manner as to retain accessibility to junction box covers and to permit future removal or replacement of ducts.
U. Non-metallic conduit changes of direction shall be made by use of large radius bends, sweeps, or offsets.
V. Steel conduit bends of same size as the non-metallic conduit shall be used to terminate non-metallic conduit underground runs above ground.
W. Steel conduit sections of the same size as the non-metallic conduit shall be used to terminate non-metallic conduit runs in handholes, power pits, building line, etc. Length of steel conduit sections shall extend a minimum of 5 feet from outside face of handhole, or power pit, building line, etc.
X. All underground conduit shall be water-tight using water-tight compounds and fittings.

3.2 INSTALLATION - FITTINGS

A. Join nonmetallic conduit using cement as recommended by manufacturer. Wipe nonmetallic conduit dry and clean before joining. Apply full even coat of cement to entire area inserted in fitting. Allow joint to cure for 20 minutes, minimum.
B. Use conduit hubs or sealing locknuts to fasten conduit to sheet metal boxes in damp and wet locations and to cast boxes.
C. Avoid moisture traps; provide junction box with drain fitting at low points in conduit system.
D. Provide conduit seals for conduits and ducts entering/exiting hazardous locations.
E. Provide suitable fittings to accommodate expansion and deflection where conduit crosses expansion joints and in each uninterrupted run of horizontal or vertical conduit in excess of 100 feet. Fittings shall be complete with bonding jumpers and clamps.
F. Use suitable caps to protect installed conduit against entrance of dirt and moisture.
G. Double locknuts shall be used at termination of IMC and HWG conduit in knock out openings.
H. Ends of conduits shall be equipped with insulating bushings for 1-inch and smaller and insulated metallic bushings for 1¼-inches and larger. Ends of conduit shall be temporarily capped prior to installation and during construction to exclude foreign material.
I. Joints in conduit run underground or in slabs on ground shall be made watertight with copper base anti corrosive conductive compound.
J. Provide wall flanges and gasketing on conduits entering fan housings to minimize air leakage at points of penetration of housing.
K. No running threads shall be cut or used.
L. Transitions between non-metallic and steel conduit shall be made by means of conduit manufacturer's standard adapters.

3.3 INSTALLATION - SUPPORTS

A. Arrange supports to prevent misalignment during wiring installation.
B. Conduit embedded in underground concrete shall be adequately supported to prevent movement during concrete placement. Compact gravel fill and soil below underground conduit or support conduit with suitable separators and chairs prior to placing concrete.
C. Support conduit using coated steel or malleable iron straps, lay in adjustable hangers, clevis hangers, and split hangers.
D. Group related conduits; support using conduit rack. Construct rack using steel channel.
E. Fasten conduit supports to building structure and surfaces under provisions of Section 16190.
F. Do not support conduit with wire or perforated pipe straps. Remove wire used for temporary supports
G. Do not attach conduit to ceiling support wires.
H. Bring conduit to shoulder of fittings; fasten securely.

I. Conduit risers shall be rigidly supported on the building structure, using appropriate supports only.
J. Installation of conduit in concrete structure shall conform to the requirements of ACI 318.
K. Sizes and spacing of conduits run in concrete shall be reviewed by the Architect/Engineer. Conduit shall not be reactive with the concrete. Conduit shall not cross-over one another.
L. Conduit embedded in concrete structure shall have a minimum cover of 1-inch to parallel concrete surface, or as otherwise specified. Parallel conduit runs within concrete shall have not less than 4-inches clear space between conduits, or spacing equal to 2 outside diameters, whichever is greater.
M. Conduit embedded in concrete shall be located by the trades concerned, between the bottom and top reinforcement. Conduit parallel to reinforcing steel shall not be supported by or tied directly to the steel. It shall be supported on bar chairs or support bars provided solely for that purpose.
N. Conduits and other electrical items shall not be fastened to or supported from ventilating ducts but shall be separately supported. The method of supporting and details of the supporting members shall be reviewed by the Architect/Engineer. In no case shall screws penetrate the sheet metal of the ducts.
O. Exposed conduits run on surfaces shall be supported according to code and within 3 feet of each outlet, junction box, or cabinet, by galvanized malleable conduit clamps and clamp backs. Suspended conduits shall be supported every 5 feet by conduit hangers and round rods, or where 2 or more conduits are run parallel, by trapeze hangers suitably braced to prevent swaying.
P. Screws for exposed work shall be stainless steel.
Q. Cadmium plated steel screws may be used for interior unexposed dry locations only.
R. All trenching, coring, backfilling and compacting for the electrical installation is by the electrical contractor. All excess debris from trenching and coring shall be removed from the site by the electrical contractor.
S. All underground site work conduit shall be minimum 36” below finished grade or below frost-line whichever is deepest. Unless noted otherwise, underground conduits shall be PVC Schedule 40. Galvanized rigid steel conduits will be used under concrete areas and thru footing, foundation, etc.

3.4 INTERFACE WITH OTHER PRODUCTS

A. Install conduit to preserve fire resistance rating of partitions and other elements, using materials and methods under the provisions of the General Requirements.
B. Route conduit through roof openings for piping and ductwork or through suitable roof jack with pipe portals. Coordinate location with roofing installation.

END OF SECTION

SECTION 16112

SURFACE RACEWAYS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS
A. The General Provisions of the Contract, including Conditions of the Contract and the General Requirements, apply to the work in this Section.
B. This Section is hereby made a part of all other sections of Division 16 as fully as if repeated in each therein.

1.2 SECTION INCLUDES
A. Surface metal raceways.
B. Multi outlet assemblies.
C. Wireways.

1.3 RELATED SECTIONS
A. Section 16140 - Wiring Devices: Receptacles.

1.4 REFERENCES
A. NECA (National Electrical Contractors Association) Standard of Installation.
B. NEMA WD 6 - Wiring Device Configurations.

1.5 SUBMITTALS
A. Submit under provisions of the General Requirements and Section and 16010.
B. Product Data: Provide for surface metal raceways, multi-outlet assemblies, wireways, finishes, and accessories.
C. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, and installation of Product.
D. Project Record Documents: Record actual locations of surface raceway and record actual circuiting arrangements in project record documents.

1.6 QUALIFICATIONS
A. Manufacturer: Company specializing in manufacturing Products specified in this Section with minimum three years' experience.

1.7 REGULATORY REQUIREMENTS
A. Conform to requirements of local electrical code, unless otherwise specified.
B. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for the purpose specified and indicated.

1.8 COORDINATION
A. Coordinate under provisions of the General Requirements and Section 16010.
B. Field Meetings: Coordinate within pre-installation meeting.
C. Field Measurements: Verify that field measurements are as shown on Drawings.

PART 2 – PRODUCTS

2.1 SURFACE METAL RACEWAY
A. Manufacturers:
   1. Wiremold, Mono-Systems, Hubbell or approved equal.
B. Description: Steel channel with fitted cover, suitable for use as surface metal raceway.
C. Size: V700 (minimum)
D. Finish: Buff enamel
E. Fittings, Boxes, and Extension Rings: Furnish manufacturer's standard accessories.

2.2 MULTIOUTLET ASSEMBLY

A. Manufacturers:
   1. Wiremold Series 4000, Hubbell 4000 Series or approved equal.
B. Multioutlet Assembly: Steel channel with fitted cover with pre-wired receptacles, suitable for use as multioutlet assembly.
C. Size: As required.
D. Receptacles: NEMA WD 6, type 5 20R, single receptacle.
E. Receptacle Spacing: 30” O.C. unless otherwise indicated on drawings.
F. Receptacle Color: Ivory or orange as indicated on drawings.
G. Finish: Buff enamel.
H. Fittings: Furnish manufacturer's standard couplings, elbows, outlet and device boxes, and connectors.

2.3 WIREWAY

A. Manufacturers:
   1. Wiremold, or equal
B. Description: General purpose type wireway.
C. Knockouts: Manufacturer's standard.
D. Size: As required to accommodate number of wires.
E. Cover: Screw cover.
F. Connector: Flanged.
G. Fittings: Lay in type with removable top, bottom, and side; captive screws.
H. Finish: Rust inhibiting primer coating with gray enamel finish.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install Products in accordance with manufacturer's instructions.
B. Use flat head screws, clips, and straps to fasten raceway channel to surfaces. Mount plumb and level.
C. Use suitable insulating bushings and inserts at connections to outlets and corner fittings.
D. Wireway Supports: Provide steel channel.
E. Close ends of wireway and unused conduit openings.
F. Ground and bond raceway and wireway.

END OF SECTION

SECTION 16123

BUILDING WIRE AND CABLE

PART 1 – GENERAL

1.1 RELATED DOCUMENTS
A. The General Provisions of the Contract, including Conditions of the Contract and Division 1 Specification Sections, apply to the work in this Section.
B. This Section is hereby made a part of all other sections of Division 16 as fully as if repeated in each therein.

1.2 SECTION INCLUDES
A. Building wire and cable.
B. Wiring connectors and connections.

1.3 RELATED SECTIONS
A. Section 16195 - Electrical Identification.
B. Section 16170 - Grounding and Bonding.

1.4 REFERENCES
A. NECA Standard of Installation (National Electrical Contractors Association).
B. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems (International Electrical Testing Association).
C. NFPA 70 - National Electrical Code.

1.5 SUBMITTALS
A. Submit under provisions of the General Requirement Specification Sections and Section 16010.
B. Product Data: Provide for each cable assembly type.
C. Test Reports: Indicate procedures and values obtained.
D. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency specified under Regulatory Requirements.
E. Project Record Documents: Record actual locations of components and circuits.

1.6 QUALIFICATIONS
A. Manufacturer: Company specializing in manufacturing products specified in this Section with minimum three years’ experience.

1.7 REGULATORY REQUIREMENTS
A. Conform to requirements of local electrical code, unless otherwise specified.
B. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for the purpose specified and indicated.

1.8 COORDINATION
A. Coordinate under provisions of the General Requirement Specification Sections and Section 16010.
B. Field Measurements: Verify that field measurements are as shown on Drawings.
C. Where wire and cable routing are shown on Drawings, it is approximate unless dimensioned. Include wire and cable lengths within 10 ft of length where shown.
D. Where wire and cable destination are indicated and routing is not shown on Drawings, determine exact routing and lengths required.

PART 2 – PRODUCTS

2.1 BUILDING WIRE

A. Manufacturers:
   1. American Insulated Wire Corp.
   2. Cerro.
   3. Collyer.
   4. Capitol Wire and Cable.
   5. Okonite.
   6. Senetor.
   7. South Wire.
   8. Triangle.

B. Description: Single conductor insulated copper wire.
   1. AWG No. 12 minimum, unless otherwise specified.
   2. AWG No. 10 and smaller may be solid or stranded, unless otherwise specified.
   3. AWG No. 8 and larger shall be stranded.
   4. AWG No. 14 stranded, for control and signal wire, unless otherwise specified.
   5. Provide wire and cable suitable for the temperature, conditions and location where indicated.
   6. Conductivity: Copper conductors shall have a conductivity of not less than 98% at 20□C (68□F). Conductor resistance values shall be in accordance with the values in NEMA WC 8.
   7. Jackets: Factory-applied nylon or PVC external jacketed wires and cables for pulls in raceways over 100-feet in length, for pulls in raceways with more than three equivalent 90□ bends, for pulls in conduits underground or under slabs on grade, and where indicated.

C. Insulation: 600 volts NFPA 70 Types as follows:
   1.

Wire Location	Line/Load terminations on OCP devices rated from 15A thru 600A -	Line/Load Terminations on 100% rated OCP devices
Interior Locations	THHN/THWN XHHW	<45°C ambient XHHW >45°C ambient
Exposed Exterior	THHN/THWN	XHHW - damp locations XHHW-2 wet locations
Below Grade	XHHW	XHHW-2

2.2 WIRING CONNECTORS

A. Solderless Insulated Mechanical Connectors:
   1. Manufacturers:
      a. Burndy DUC.
      b. Dossert GTC.
      c. OZ/Gedney XTPC.
      d. Thomas & Betts CTC.
   2. Provide parallel clamp connector with insulating cover.
   3. Connector shall be constructed of an all copper alloy with bolted tangential plates which will receive the clamping pressure and redistribute the pressure uniformly over the entire surface of the clamping mechanism.

4. Insulating cover shall be of the same manufacturer as the connectors and shall have cable openings suitable for the cable insulation being installed. Where insulating covers do not completely seal taps, tape the installation. The insulating cover shall not kink or crimp the cable insulation when cover is completely closed.

B. Spring Wire Connectors:
   1. Manufacturers:
      a. Thomas & Betts PT.
      b. 3M Scotchloc.
C. Compression Connectors:
   1. Manufacturers:
      a. Burndy Hydent.
      b. Thomas & Betts 54000.
   2. One-hole lugs for AWG No. 4/0 and smaller.
   3. Two-hole lugs for AWG No. 250 kcmil and larger.
   4. Feeders 1200 Amps and larger shall include cable limiter type lugs at each end of each phase conductor.

2.3 ADDITIONAL ACCESSORIES

A. In the event that conduit and wire sizes increase beyond the motor or equipment manufacturer's normal provisions for conduit and wire terminations, due to voltage-drop or other considerations in motor branch-circuit designs, provide necessary auxiliary termination facilities with adequate boxes, lugs, terminals, and other components as may be required. Consult with the suppliers of motors and other items to ensure that the equipment is furnished with suitable components to accept the required conduits and wires.
B. Riser cables shall have cable supports as required by code.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Verify that interior of building has been protected from weather.
B. Verify that raceway installation is complete and supported.

3.2 PREPARATION

A. Completely and thoroughly swab raceway before installing wire.
B. Install wiring in conduits buried in plaster or in poured concrete after the encasing medium is set and dry.

3.3 INSTALLATION

A. Route wire and cable as required to meet Project Conditions.
B. Install cable in accordance with the NECA "Standard of Installation."
C. Pull all conductors into raceway at same time.
D. Use pulling means including fish tape, cable, rope and basket weave wire/cable grips which will not damage cables or raceways.
E. Feeders shall be installed as continuous conductors without splices whenever possible. Where feeder splices are required, the contractor shall submit a request for approval in writing to the engineer indicating the feeder and splice location. Where splices are installed without written approval, the engineer reserves the right to have the contractor replace the spliced conductors with continuous conductors at no additional cost to the Owner.
F. Use suitable wire pulling lubricant for building wire 4 AWG and larger.
   1. Cable lubricants shall be less than 6 percent solid residue after drying for 24 hours at 105°C. Cable lubricants shall not contain any waxes, greases, polyakylene glycol oils, or silicones. Manufacturer: Polywater J by American Polywater Corp.
G. Protect exposed cable from damage. Install exposed cable, parallel and perpendicular to surfaces, or exposed structural members, and follow surface contours, where possible.

H. Support signal cables above accessible ceiling, using cable ties to support cables from structure. Do not rest cable on ceiling grid.
I. Use suitable cable fittings, connectors, and supports.
   1. Cable supports shall be as required by Code and shall be compatible with the wire and cable type and the associated conduit size.
      a. Manufacturer: OZ/Gedney or Thomas & Betts.
J. Increase conductor size as required due to availability. Minimum feeder conductor sizes are shown on Drawings. If increased, be responsible for associated feeder conduit size and increased ground conductor size per NEC.
K. Provide conductors of the same size from the protective device to the last load.
L. Make conductor length identical for parallel feeders.
M. Support conductors in vertical raceways. One cable support shall be provided at the top or as close to the top as practical, plus a support for each additional interval of spacing per Table 300-19a of the NEC.
N. Provide slack wire for all future connections with ends of wires taped and blank box covers installed.
O. Do not bend cables, either permanently or temporarily during installation, to radii less than that recommended by the manufacturer.
P. Use conductors with 90□C insulation when wiring is within seven feet of, passing over or attached to the following:
   1. Boilers.
   2. Hot water heaters.
   3. Other heat producing equipment.
Q. Neatly train and lace wiring inside boxes, equipment, and panelboards.
R. Splices, Taps and Terminations
   1. Make splices and taps in wiring #10 AWG and smaller mechanically and electrically secure with mechanical pressure type splicing devices.
   2. Make splices and taps of conductors #8 AWG or larger and all splices in motor terminal boxes using compression connectors requiring the use of compression tools for securing the conductors in the connectors. Termination of conductors at all distribution equipment, except transformers, shall be made using mechanical lugs. Connectors shall be of high conductivity, corrosion-resistant material and have actual contact area that shall provide at least the current carrying capacity of the wire or cable. For conductors #1/0 and larger, connector lugs shall be of the two-hole type. Connector lugs shall be bolted to bussing using Belleville washers in combination with flat washers and nuts.
   3. Each conductor lug or bus shall be individually made with separate lug and/or bolt as required for the termination.
   4. Provide insulated connectors for splices and taps with a self-fusing rubber insulating tape that is non-corrosive to the connector and the conductor. Insulation tape shall have a minimum of 350 volts per mil dielectric strength. Friction or vinyl tape shall be applied directly over rubber insulating tape equal to 3M Scotch 88 type.
S. Tighten electrical connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values. Where manufacturer's torque-ing requirements are not indicated, tighten connector and terminals to comply with tightening torques specified in UL Standards 486A and B.

T. Identify and color code wire and cable under provisions of Section 260553. Identify each conductor with its circuit number or other designation indicated. Wire color coding shall be as follows or as required by local codes:

Normal Power	**Powered from TVSS Panel**
120/208 Volts:	120/208 Volts:
Phase A – Black	Phase A - Purple
Phase B – Red	Phase B - Pink
Phase C – Blue	Phase C - Tan
Neutral – White	Neutral – White with Gray Stripe
Ground – Green	Ground – Green with Orange Stripe
277/480 Volts:	
Phase A – Brown	
Phase B – Orange	
Phase C – Yellow	
Neutral – Gray	
Ground – Green	

3.4 MAXIMUM BRANCH CIRCUIT LENGTHS

A. The following indicates maximum installed length a circuit can have and still maintain an adequate voltage level at the last point of use for 20-amp circuit. If the 20-amp circuit length exceeds the length listed, use the next larger wire sized. Multiple circuit runs in the same raceway shall have all conductors sizes the same based on worst case circuit lengths.

BRANCH CIRCUIT LENGTH (IN FEET)

Wire Size	2 Wire 120 V	2 Wire 277 V	1 Phase 208V	1 Phase 480 V	3 Phase 208 V	3 Phase 480 Volt
12	0 to 61'	0 to 141'	0 to 105'	0 to 244'	0 to 122'	0 to 282'
10	62' to 97'	142' to 224'	106' to 168'	245' to 388'	123' to 194'	283' to 449'
8	98' to 154'	225' to 357'	169' to 267'	389' to 618'	195' to 309'	450' to 714'
6	155' to 246'	358' to 567'	268' to 426'	619' to 983'	310' to 491'	715' to 1135'

3.5 FIELD QUALITY CONTROL

A. Testing: Upon installation of wires and cables and before electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
   1. Procedures: Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification, Section 7.3.1. Certify compliance with test parameters.

B. Correct malfunctioning products at site, where possible, and retest to demonstrate compliance; otherwise remove and replace with new units, and retest.

C. Inspection: Inspect wire and cable for physical damage and proper connection.

D. Insulation Resistance Test: Prior to energization of circuitry, check installed wires and cables with megaohm meter to ensure insulation resistance requirements are fulfilled.

E. Continuity Test: Perform continuity test on all power and equipment branch circuit conductors. Verify proper phasing connections. Correct if necessary.

F. Branch Circuits with Receptacles: Branch circuit receptacle wiring shall be tested using a Daniel Woodhead Co. circuit tester Model #1750.

G. Torque Test: Torque test conductor connections and terminations to manufacturer’s recommended values.

END OF SECTION

SECTION 16130

BOXES

PART 1 – GENERAL

1.1 RELATED DOCUMENTS
A. The General Provisions of the Contract, including Conditions of the Contract and the General Requirement Specification Sections, apply to the work in this Section.
B. This Section is hereby made a part of all other sections of Division 16 as fully as if repeated in each therein.

1.2 SECTION INCLUDES
A. Wall and ceiling outlet boxes.
B. Floor boxes.
C. Pull and junction boxes.

1.3 RELATED SECTIONS
A. Section 16140 - Wiring Devices.
B. Section 16170 - Grounding and Bonding.
C. Section 16190 - Supporting Devices.
D. Section 16195 - Electrical Identification.

1.4 REFERENCES
A. NECA (National Electrical Contractors Association) Standard of Installation.
B. NEMA FB 1 - Fittings and Supports for Conduit and Cable Assemblies.
C. NEMA OS 1 - Sheet Steel Outlet Boxes, Device Boxes, Covers, and Box Supports.
D. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
E. Local electrical code.

1.5 SUBMITTALS
A. Submit under provisions of General Requirement Specification Sections and Sections 16010.
B. Product Data: Provide for outlet boxes and floor boxes.
C. Project Record Documents: Record actual locations and mounting heights of outlet boxes, floor boxes, junction boxes, and pull boxes.

1.6 QUALIFICATIONS
A. Manufacturer: Company specializing in manufacturing Products specified in this Section with minimum three years' experience.

1.7 REGULATORY REQUIREMENTS
A. Conform to requirements of local electrical code.
B. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for the purpose specified and indicated.

1.8 COORDINATION
A. Coordinate under provisions of the General Requirement Specification Sections and Section 16010.
B. Field Measurements: Verify that field measurements are as shown on Drawings.
C. Field Locations: Verify locations of boxes prior to installation.

PART 2 – PRODUCTS

2.1 OUTLET BOXES

A. Manufacturers:
   1. Appleton
   2. Raco
   3. Steel City
B. Sheet Metal Outlet Boxes: NEMA OS 1, galvanized steel with knockouts.
   1. Luminaire and Equipment Supporting Boxes: Rated for weight of equipment supported; include ½-inch male fixture studs where required.
   2. Concrete Ceiling Boxes: Concrete type.
C. Cast Boxes: NEMA FB 1, Type FD, cast feralloy. Provide gasketed cover and threaded hubs.
D. Wall Plates for Finished Areas: As specified in Section 16140.

2.2 PULL AND JUNCTION BOXES

A. Sheet Metal Boxes: NEMA OS 1.
   1. Material: Hot-dipped galvanized steel.
   2. Covers: Secured with stainless steel screws.
   3. Finish: Paint interior and exterior with rust-inhibitive paint.
   4. Gaskets: Provide in accordance with applicable Code.
B. Hinged Enclosures: As specified.
C. Surface Mounted Cast Metal Box: NEMA 250, flat flanged, surface mounted junction box:
   1. Material: Galvanized cast iron.
   2. Cover: Furnish with ground flange, neoprene gasket, and stainless-steel cover screws.
D. In Ground Cast Metal Box: NEMA 250, Type 6, flanged, recessed cover box for flush mounting:
   1. Material: Galvanized cast iron.
   2. Cover: Nonskid cover with neoprene gasket and stainless-steel cover screws.
E. Fiberglass Handholes: Die molded glass fiber hand holes:
   1. Cable Entrance: Pre-cut 6-inch x 6-inch cable entrance at center bottom of each side.
   2. Cover: Glass fiber weatherproof cover with nonskid finish.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Verify locations and mounting heights of floor boxes and outlets prior to rough in.

3.2 INSTALLATION

A. Install boxes in accordance with NECA "Standard of Installation."
B. Install in locations as shown on Drawings, and as required for splices, taps, wire pulling, equipment connections and compliance with regulatory requirements.
C. Set wall mounted boxes at elevations to accommodate mounting heights indicated.
D. Electrical boxes are shown on Drawings in approximate locations unless dimensioned. Adjust box location up to 10 feet if required to accommodate intended purpose.
E. Box sizes shall not be smaller than that required by Code for the number and size of wires and/or conduits to be installed.
F. Orient boxes to accommodate wiring devices oriented as specified in Section 16140.
G. Maintain headroom and present neat mechanical appearance.
H. Install pull boxes and junction boxes above accessible ceilings and in unfinished areas only.
I. Inaccessible Ceiling Areas: Install outlet and junction boxes no more than 6 inches from ceiling access panel or from removable recessed luminaire.
J. Plenum Ceiling Areas: Install boxes in accordance with applicable Code.

K. Install boxes to preserve fire resistance rating of partitions and other elements, using materials and methods specified in the General Requirements.
L. Coordinate mounting heights and locations of outlets mounted above counters, benches, and backsplashes.
M. Locate outlet boxes to allow luminaires positioned as shown on reflected ceiling plan.
N. Align adjacent wall mounted outlet boxes for switches, thermostats, and similar devices.
O. Outlet boxes for toggle switches shall be located on the strike side of the door.
P. Use flush mounting outlet box in finished areas.
Q. Locate flush mounting box in masonry wall to require cutting of masonry unit corner only. Coordinate masonry cutting to achieve neat opening.
R. Do not install flush mounting box back to back in walls; provide minimum 6 inches separation. Provide minimum 24 inches separation in acoustic rated walls.
S. Secure flush mounting box to interior wall and partition studs. Accurately position to allow for surface finish thickness.
T. Use stamped steel bridges to fasten flush mounting outlet box between studs.
U. Install flush mounting box without damaging wall insulation or reducing its effectiveness.
V. Use adjustable steel channel fasteners for hung ceiling outlet box.
W. Do not fasten boxes to ceiling support wires.
X. Support boxes independently of conduit.
Y. Use gang box where more than one device is mounted together. Do not use sectional box.
Z. Use gang box with plaster ring for single device outlets.
AA. Use cast outlet box in exterior locations and wet locations.

3.3 INTERFACE WITH OTHER PRODUCTS

A. Coordinate installation of outlet box for equipment connected under Section 16180.

3.4 ADJUSTING

A. Adjust installed work under the provisions of the General Requirements.
B. Adjust floor box flush with finish flooring material.
C. Adjust flush mounting outlets to make front flush with finished wall material.
D. Install knockout closures in unused box openings.

3.5 CLEANING

A. Clean installed work under the provisions of the General Requirements Specification Sections.
B. Clean interior of boxes to remove dust, debris, and other material.
C. Clean exposed surfaces and restore finish.

END OF SECTION

SECTION 16139

CABLE TRAYS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contact, including General and Supplementary Conditions and Division 01 Specification Section, apply to this Section.

1.2 SUMMARY

A. This section includes steel cable trays and accessories.
B. Related Sections include the following:
   1. Section 16170 - Grounding and Bonding for Electrical Systems.
   2. Section 16190 - Hangers and Supports for Electrical Systems

1.3 REFERENCES

A. NFPA 70 - National Electrical Code.
B. ASTM International:
   1. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
   2. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
C. National Electrical Manufacturers Association:
   1. NEMA VE 1 - Metal Cable Tray Systems.
   2. NEMA VE 2 - Metal Cable Tray Installation Guidelines.

1.4 COORDINATION

A. Coordinate under provisions of Division 1 and Division 16.
B. Field Meetings: Coordinate within pre-installation meeting.
C. Field Measurements: Verify that field measurements are as shown on Drawings.

1.5 SUBMITTALS

A. Submittal Procedures: Submittal procedures.
B. Product Data: Include data indicating dimensions and finishes for each type of cable tray indicated.
C. Shop Drawings: For each type of cable tray.
   1. Show fabrication and installation details of cable tray, including plans, elevations, and sections of components and attachments to other construction elements. Designate components and accessories, including clamps, brackets, hanger rods, splice-plate connectors, expansion-joint assemblies, straight lengths, and fittings.
D. Coordination Drawings: Floor plans and sections, drawn to scale. Include scaled cable tray layout and relationships between components and adjacent structural, electrical, and mechanical elements. Show the following:
   1. Vertical and horizontal offsets and transitions.
   2. Clearances for access above and to side of cable trays.
   3. Vertical elevations of cable trays above the floor or bottom of ceiling structure.
E. Manufacturer's Installation Instructions: Submit application conditions and limitations of use stipulated by Product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, and installation of Product.
F. Project Record Documents: Record actual routing of cable tray and locations of supports.
G. Field quality-control reports.
H. Operation and Maintenance Data: For cable trays to include in emergency, operation, and maintenance manuals.

1.6 QUALITY ASSURANCE

A. Source Limitations: Obtain cable tray components through one source from a single manufacturer.
B. 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.
C. Comply with NFPA 70.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Store indoors to prevent water or other foreign materials from staining or adhering to cable tray. Unpack and dry wet materials before storage.

1.8 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing Products specified in this section with minimum ten years documented experience.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Cooper B-Line, Inc.
   2. Cope, T.J., Inc.; a subsidiary of Allied Tube & Conduit.
   3. MONO-SYSTEMS, Inc.
   4. MPHusky.
   5. PW Industries.
   6. Square D (Schneider).

2.2 MATERIAL AND FINISHES

A. Cable Trays, Fittings, and Accessories: Steel, Sold Bottom, complying with NEMA VE 1.
   1. Factory-standard primer, ready for field painting; with cadmium-plated hardware according to ASTM B 766.
   2. All cable trays mounted in areas that are exposed to eyesight from below shall be painted flat black to match surroundings. All cables must be concealed from view.
   3. Cable trays shall be mounted on one side only, or center-mounted, to allow for future installation of cable from the side(s).
B. Cable Trays, Fittings, and Accessories: Aluminum, Solid Bottom, complying with NEMA VE 1, Aluminum Association's Alloy 6063-T6 for rails, rungs, and cable trays, and Alloy 5052-H32 or Alloy 6061-T6 for fabricated parts; with splice-plate fasteners, bolts, and screws.
C. Cable Trays, Fittings, and Accessories: Solid Bottom, complying with NEMA VE 1.

2.3 CABLE TRAY ACCESSORIES

A. Fittings: Tees, crosses, risers, elbows, and other fittings as indicated, of same materials and finishes as cable tray.
B. Barrier Strips: Same materials and finishes as cable tray.
C. Cable tray supports and connectors, including bonding jumpers, as recommended by cable tray manufacturer.

2.4 SOURCE QUALITY CONTROL

A. Perform design and production tests according to NEMA VE 1.

PART 3 - EXECUTION

3.1 INSTALLATION - CABLE TRAY

A. Comply with recommendations in NEMA VE 2. Install as a complete system, including all necessary fasteners, hold-down clips, splice-plate support system, barrier strips, hinged horizontal and vertical splice plates, elbows, reducers, tees, and crosses.
B. Remove burrs and sharp edges from cable trays.
C. Fasten cable tray supports to building structure.
   1. Place supports so that spans do not exceed maximum spans per manufacturer recommendations.
   2. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.
   3. Support bus assembly to prevent twisting from eccentric loading.
   4. Manufacturer center-hung support, designed for 60 percent versus 40 percent eccentric loading condition, with a safety factor of 3.
   5. Locate and install supports according to NEMA VE 1.
D. Make connections to equipment with flanged fittings fastened to cable tray and to equipment. Support cable tray independent of fittings. Do not carry weight of cable tray on equipment enclosure.
E. Install expansion connectors where cable tray crosses building expansion joint and in cable tray runs that exceed recommended in NEMA VE 1. Space connectors and set gaps according to applicable standard.
F. Make changes in direction and elevation using standard fittings.
G. Make cable tray connections using standard fittings.
H. Seal penetrations through fire and smoke barriers according to “Penetration Firestopping” Section.
I. Workspace: Install cable trays with enough space to permit access for installing cables.
J. Install barriers to separate cables of different systems, such as power, communications, and data processing; or of different insulation levels, such as 600, 5000, and 15,000V.

3.2 INSTALLATION – CABLE

A. Install cables only when cable tray installation has been completed and inspected.
B. Fasten cables on horizontal runs with cable clamps or cable ties as recommended by NEMA VE 2. Tighten clamps only enough to secure the cable, without indenting the cable jacket. Install cable ties with a tool that includes an automatic pressure-limiting device.
C. On vertical runs, fasten cables to tray every 18 inches (457 mm). Install intermediate supports when cable weight exceeds the load-carrying capacity of the tray rungs.

3.3 CONNECTIONS

A. Ground cable trays according to manufacturer’s written instructions.
B. Install a bare copper equipment grounding conductor with cable tray, in addition to those required by NFPA 70 – minimum #2 AWG.
C. Refer to Division 16 Section 16170 “Grounding and Bonding”.

3.4 FIELD QUALITY CONTROL

A. After installing cable trays and after electrical circuitry has been energized, survey for compliance with requirements. Perform the following field quality-control survey:
   1. Visually inspect cable insulation for damage. Correct sharp corners, protuberances in cable tray, vibration, and thermal expansion and contraction conditions, which may cause or have caused damage.
   2. Verify that the number, size, and voltage of cables in cable tray do not exceed that permitted by NFPA 70. Verify that communication or data-processing circuits are separated from power circuits by barriers.
   3. Verify that there is no intrusion of such items as pipe, hangers, or other equipment that could damage cables.

4. Visually inspect each cable tray joint and each ground connection for mechanical continuity. Check bolted connections between sections for corrosion. Clean and retorque in suspect areas.
5. Check for missing or damaged bolts, bolt heads, or nuts. When found, replace with specified hardware.
6. Perform visual and mechanical checks for adequacy of cable tray grounding; verify that all takeoff raceways are bonded to cable tray.

B. Report results in writing.

3.5 PROTECTION

A. Protect installed cable trays.
1. Repair damage to galvanized finishes with zinc-rich paint recommended by cable tray manufacturer.
2. Repair damage to paint finishes with matching touchup coating recommended by cable tray manufacturer.
3. Install temporary protection of cables in open trays to protect exposed cables from falling objects or debris during construction. Temporary protection for cables and cable tray can be constructed of wood or metal materials until the risk of damage is over.

END OF SECTION

SECTION 16140

WIRING DEVICES

PART 1 – GENERAL

1.1 RELATED DOCUMENTS
A. The General Provisions of the Contract, including Conditions of the Contract and the General Requirement Specification Sections, apply to the work in this Section.
B. This Section is hereby made a part of all other sections of Division 16 as fully as if repeated in each therein.

1.2 SECTION INCLUDES
A. Wall switches.
B. Receptacles.
C. Device plates and decorative box covers

1.3 RELATED SECTIONS
A. Section 16130 - Boxes.

1.4 REFERENCES
A. NECA - (National Electrical Contractors Association) Standard of Installation.
B. NEMA WD 1 - General Requirements for Wiring Devices.
C. NEMA WD 6 - Wiring Device Dimensional Requirements.
D. NFPA 70 – National Electrical Code.

1.5 SUBMITTALS
A. Submit under provisions of the General Requirements and Section 16010.
B. Product Data: Provide for wiring devices, device plates, and fittings. Include manufacturer's catalog information showing dimensions, colors, and configurations.
C. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, and installation of Product.
D. Project Record Documents: Record actual locations of devices and record actual circuiting arrangements in project record documents.

1.6 QUALIFICATIONS
A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years' experience.

1.7 REGULATORY REQUIREMENTS
A. Conform to requirements of local electrical code, unless otherwise specified.
B. Furnish Products listed and classified by Underwriters Laboratories, Inc. as suitable for the purpose specified and indicated.

1.8 COORDINATION
A. Coordinate under provisions of the General Requirements and Section 16010.

PART 2 – PRODUCTS

2.1 WALL SWITCHES
A. Manufacturers:
   1. Pass and Seymour.
   2. No Substitutions.

B. Specification Grade Toggle Style: 20A., 120-277V., back and side wired.

	Pass and Seymour
1P	CS20AC1
2P	CSB20AC2
3W	CSB20AC3
4W	CSB20AC4
1P-K	PS20AC1-L
1P-PL	PS20AC1-RPL
3W-PL	PS20AC3-RPL

C. Legend: 1P=single-pole, 2P=double-pole, 3W=three-way, 4W=four-way, K=keyed, PL=pilot light, MC=momentary contact.

D. Color: Ivory or red, unless otherwise specified. Final color selection shall be by the Architect.

2.2 WALL RECEPTACLES

A. Manufacturers:
   1. Pass and Seymour.
   2. No Substitutions.

B. Description: Receptacles shall be constructed to include a grounding pole from which a wired connection to ground shall be provided.

C. Specification Grade Traditional Style: 20A., 120V., NEMA 5-20R, back and side wired.

	Pass and Seymour
S	5361
D	
C	S3733-SS
GFI	2095
IG	IG5362-OSP
HG-S	8301
HG-D	8300
HG-GFI	2095-HG
HG-IGI	IG8300
TR	TR63

D. Range Outlet: 50A., 125/250V., NEMA 10-50R.

	Pass and Seymour
Single	3890

E. Combination Outlet: 15A., 125/250V., NEMA 5-15R & 6-15R.

	Pass and Seymour
Duplex	5290

F. Special NEMA configurations shall be specification grade, unless otherwise specified.

G. Color: Ivory or red, unless otherwise specified. Emergency devices: Red, unless otherwise specified. Final color selection shall be by the Architect.

H. Legend: S=single, D=duplex, C=clock hanger, GFI=ground fault, IG=isolated ground, TR=tamper resistant, HG = Hospital Grade.

2.3 WALL PLATES

A. Manufacture: Match switch and receptacle manufacture. Provide matching cover plates for switches and receptacles within same area, unless otherwise specified.
B. Standard Cover Plate: Brushed stainless steel.
C. Weatherproof Cover Plate: Gasketed corrosion resistant cast metal with hinged and gasketed device cover.

2.4 FIRE RATED POKE THROUGH DEVICES

A. Manufacturers
   1. Hubbell or approved equal.
B. Description: Must be flush with floor and utilize a 4” core. Must meet a 4-hour fire rating and must meet or exceed UL514A Scrub Water Requirements. Provide IG receptacle and IG wiring where poke-through is used for an IG outlet.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Verify that device types, traditional or designer, finishes, and colors are in conformance with the Architects direction.
B. Verify that outlet boxes are installed at proper height.
C. Verify that outlet boxes for light switches are on strike side of door.
D. Verify that wall openings are neatly cut and will be completely covered by wall plates.
E. Verify that floor boxes are adjusted properly.
F. Verify that outlet boxes for wall dimmers are adequately sized to achieve full rating specified and indicated after derating for ganging as instructed by manufacturer.
G. Verify that exterior, wet locations, and other locations required by authority having jurisdiction, are provided with GFI type devices.
H. Verify that branch circuit wiring installation is completed, tested, and ready for connection to wiring devices.

3.2 PREPARATION

A. Provide extension rings to bring outlet boxes flush with finished surface.
B. Clean debris from outlet boxes.

3.3 INSTALLATION

A. Install in accordance with NECA "Standard of Installation."
B. Install fittings in accordance with manufacturer’s instructions.
C. Install devices plumb and level.
D. Install switches with OFF position down.
E. Install wall dimmers to achieve full rating specified and indicated after derating for ganging as instructed by manufacturer.
F. Do not share neutral conductor on load side of dimmers.
G. Install receptacles with grounding pole on right side.
H. Connect wiring device grounding terminal to separate green branch circuit equipment grounding conductor.
I. Install stainless-steel plates on switch, receptacle, and blank outlets in finished areas.
J. Connect wiring devices by wrapping conductor around screw terminal.
K. Use standard size stainless-steel plates for outlets installed in masonry walls.
L. Install galvanized steel plates on outlet boxes and junction boxes in unfinished areas, above accessible ceilings, and on surface mounted outlets.
M. Install protective rings on active flush cover service fittings.

3.4 INTERFACE WITH OTHER PRODUCTS

A. Coordinate locations of outlet boxes provided under Section 16130 to obtain mounting heights as specified.
B. Coordinate the installation of wiring devices with furniture systems.

3.5 FIELD QUALITY CONTROL

A. Field inspection and testing will be performed under provisions of the General Requirements.
B. Inspect each wiring device for defects.
C. Operate each wall switch with circuit energized and verify proper operation.
D. Verify that each receptacle device is energized.
E. Test each receptacle device for proper polarity.
F. Test each GFI receptacle device for proper operation.

3.6 ADJUSTING

A. Adjust installed work under the provisions of the General Requirements.
B. Adjust devices and wall plates to be flush and level.

3.7 CLEANING

A. Clean installed work under the provisions of the General Requirements.
B. Clean exposed surfaces to remove splatters and restore finish.

END OF SECTION

SECTION 16150

OCCUPANCY SENSORS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS
A. The General Provisions of the Contract, including Conditions of the Contract and the General Requirement of Specifications, apply to the work in this Section.
B. This Section is hereby made a part of all other sections of Division 16 as fully as if repeated in each therein.

1.2 SECTION INCLUDES
A. Occupancy sensors.
B. Power pack.

1.3 RELATED SECTIONS
A. Section 16130 - Boxes.

1.4 REFERENCES
A. Underwriters Laboratories Inc. – UL508, UL916.
B. ISO 9001 Quality Standard
C. NOM Certification Mark
D. American National Standards Institute
E. Institute of Electrical and Electronic Engineers

1.5 SUBMITTALS
A. Submit manufacturer's standard catalog data giving all application, wiring, and installation information on basic components. Provide test data and/or samples as required to demonstrate conformance with PART 2 of this specification.
B. Submit a lighting plan clearly marked by manufacturer showing proper product, location and orientation of each sensor
C. Submit any interconnection diagrams per major subsystem showing proper wiring.
D. Shall include a load schedule which indicates the actual connected load and load type per circuit, circuits and their respective control zones, circuits that are on emergency (if applicable), and the capacity, phase, and corresponding circuit numbers (per the electrical drawings).
E. Shall include all exceptions taken to the Specification.

1.6 APPROVALS
A. Prior approval is required for alternate proposals. For pre-approval, provide all the information listed under Submittals a minimum of ten (10) working days prior to initial bid date.
B. Complete Catalog data, specifications, and technical information on alternate equipment must be furnished to the Architect and Owner at least ten business days in advance of the bid date.

1.7 QUALITY ASSURANCE
A. Manufacturer shall have a minimum of 10 years continuous experience with occupancy sensors.
B. Occupancy sensors shall be UL, CUL or NOM listed (where appropriate). Manufacturer shall provide evidence of compliance on request.
C. Manufacturer shall have their quality system registered to the ISO 9001 Quality Standard, including in-house engineering for all product design activities. Due to the exclusion of the Design Control element, ISO 9002 Registration is not acceptable.
D. All devices shall be covered by a minimum one-year warranty.

1.8 PROJECT/SITE CONDITIONS
A. Lighting controls shall operate in an ambient temperature range of 0°C (32°F) to 40°C (104°F) and less than 90% non-condensing relative humidity without the requirement of a regularly scheduled maintenance program.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

A. Leviton.
B. No Substitutions.

2.2 CEILING MOUNTED OCCUPANCY SENSOR

A. Leviton OSC10 – M0W.
B. Sensors and related relays shall be compatible with the specific lighting types controlled.
C. All sensors shall be of the same manufacturer, mixing brands of sensors is not acceptable.
D. All sensors and related equipment shall have a five-year warranty.
E. All sensors and control modules shall be listed by Underwriters Laboratories.
F. Sensor shall incorporate ultrasonic and infrared technologies in a single unit for corridor or rooms. For washroom and stair-only ultrasonic type sensor shall be used.
G. Sensor shall be Class 2, low voltage; capable of mounting in the ceiling for maximum coverage.
H. Sensor shall use internal microprocessor for motion signal analysis and automatic self-adjustment.
I. Sensor shall have automatic self-adjustment algorithm which adjusts timer and sensitivity settings to maximize performance and minimize energy usage.
J. Sensor shall have manual time-out adjustment from 8 minutes to 32 minutes and automatic time-out from 8 minutes to 100 minutes.
K. Sensor shall have test time-out setting of 8 seconds, with automatic return to 8 minutes after one hour if sensor is left in test mode.
L. Sensor's microprocessor shall automatically reduce either PIR or ultrasonic sensitivity in response to false on condition.
M. Sensor microprocessor will automatically monitor PIR background threshold signal level and makes corresponding sensitivity adjustments automatically.
N. Sensor microprocessor algorithm shall incorporate automatic adaptation to continuous airflow.
O. Infrared lens shall have 360-degree field of view. Two types of lens shall be available, standard and extra dense.
P. Sensor shall have a variety of mask inserts for PIR coverage rejection to prevent false tripping.
Q. Sensor shall have a rugged plastic housing, white in color.
R. Transducers shall be protected from tampering.
S. Sensor shall have manual adjustments for timer and sensitivities and override switches to force manual adjustment mode.
T. Sensor shall have adjustable sensitivity from 0% to 100% for both ultrasonic and infrared.
U. Controls shall be behind cover to resist tampering. All adjustments shall be accessible from the front of the sensor.
V. Sensor shall be available with a photocell adjustment from 20 to 3,000 Lux.
W. Sensor shall provide internal operating status and settings confirmation via LED motion lamp indicator.
X. Sensor shall have two (if 180 degree) or three (if 360 degree) real time LED motion indicators visible from the front of the unit: Red = Infrared; green = ultrasonic.
Y. Sensor shall be available with a set of form 1C isolated dry relay contacts for interfacing sensor to auxiliary systems. Relay shall provide common, normally open and normally closed connections.

2.3 WALL MOUNTED OCCUPANCY SENSOR

A. Leviton OSSMT-GDI.
B. Sensor shall utilize active ultrasonics to detect motion.
C. Sensor shall have two ultrasonic transmitters and one receiver, each 18mm in diameter, and shall operate at 32.768kHz.
D. Sensor shall incorporate an inrush current limiter circuit to protect the relay contacts.
E. Sensor shall utilize a dry relay contact for control of the lighting load.

F. Sensor shall have a time out adjustment from 8 seconds to 32 minutes. Timer shall be linear and controlled by a timer chip.
G. Sensor shall have automatic sensitivity adjustment and be microprocessor controlled.
H. Sensor shall have automatic gain setback to reduce the sensitivity after the sensor has turned off the lighting to prevent false tripping.
I. Sensor shall have transmitter control adjustments to prevent false tripping from hallway traffic.
J. Sensor shall have a 180-degree field of view, coverage up to 800 square feet, and shall detect six inches of hand movement towards the sensor at a distance of 22 feet. Sensor shall detect body motion towards the sensor at a distance of 32 feet.
K. Sensor shall operate at 120VAC and 277VAC.
L. Sensor shall have automatic on/off controls and also a manual override switch to disconnect power to the lighting load.
M. Sensor shall have a real time motion indicator on the front of the unit.
N. Sensor shall mount to a single or double gang switch box.
O. Sensor shall have a high impact injection molded housing.
P. Sensor shall be available with a second isolated dry relay for control of a second circuit. Relay shall be rated for 600 watts at 120VAC and 1400 watts at 277VAC. Applications shall include restroom fans.
Q. Sensor for restroom application shall be tamper resistant, incorporation a recessed automatic to off switch.

2.4 OCCUPANCY SENSOR POWER/CONTROL PACK

A. LEVITON OPP20-OD2.
B. Control module shall consist of a DC power supply and a dry contact relay for switching a lighting load.
C. Control module shall be available in versions to accept 120, 230, 277 and 347VAC line voltages.
D. Output shall be 24VDC nominal, and shall be inherently safe, low voltage, limited power output (Class 2).
E. Output shall supply 100mA current, in addition to current consumed internally to operate internal relay.
F. Relay shall utilize normally open, silver alloy dry contacts, and shall be rated for a 20A ballast load at 120V, 230V, 277V and 347V.
G. Relay function shall not require more than 5 mA control current to operate.
H. Control module shall have line voltage wiring, consisting of input voltage and relay contact connections, exiting from one end, and low voltage DC connections, consisting of ground, power, and control wires, exiting from the other end.
I. Control module shall be sized to fit inside a standard 4” X 4” junction box.
J. Control module shall be equipped with a ½“-EMT threaded male fitting on the line voltage end, such that it may be mounted to the outside of a junction box with the line voltage wiring internal to the box and the low voltage wiring external.
K. Slave module shall be available for switching additional circuits. Slave module has same construction and specifications as control module except without power supply function.

PART 3 – EXECUTION

3.1 INSTALLATION

A. It shall be the contractor's responsibility to locate and aim sensory in the correct location required for a complete and proper volumetric coverage within the range of coverage(s) of controlled areas per the manufacturer's recommendations. Rooms shall have (90) to one hundred (100) percent coverage to completely cover the controlled area to accommodate all occupancy habits of single or multiple occupants at any location within the room(s). The locations and quantities of sensors shown on the drawings are diagrammatic and indicate only the rooms which are to be provided with sensors. The contractor shall provide additional sensors if required to properly and completely cover the respective room.

B. Contractor shall furnish all equipment, labor, system setup and other services necessary for the proper installation of the products/system as indicated on the drawings and specified herein.

C. Devices shall be installed utilizing manufacturer's recommended application, wiring and installation instructions.

D. Proper judgment shall be exercised in executing the installation so as to ensure the best possible installation in the available space and to overcome local difficulties due to space limitation or interference of structural components. The contractor shall also provide at the owner's facility, the training necessary to familiarize the owner's personnel with the operation, use, adjustment, and problem-solving diagnosis of the occupancy sensing devices and systems.

3.2 FIELD QUALITY CONTROL

A. Locate sensor such that it provides the best coverage.

B. Adjust settings per manufacturer's recommendations.

END OF SECTION

SECTION 16170

GROUNDING AND BONDING

PART 1 – GENERAL

1.1 RELATED DOCUMENTS
A. The General Provisions of the Contract, including Conditions of the Contract and the General Requirement Specification Sections, apply to the work in this Section.
B. This Section is hereby made a part of all other sections of Division 16 as fully as if repeated in each therein.

1.2 SECTION INCLUDES
A. Grounding electrodes and conductors.
B. Equipment grounding conductors.
C. Bonding.

1.3 REFERENCES
A. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems (International Electrical Testing Association).
B. Local Electrical Code.

1.4 SUBMITTALS
A. Submit under provisions of the General Requirements and Section 16010.
B. Product Data: Provide for grounding electrodes and connections.
C. Test Reports: Indicate overall resistance to ground and resistance of each electrode.
D. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, and installation of Product.
E. Project Record Documents: Record actual locations of components and grounding electrodes.
F. Certificate of Compliance: Submit detailed drawings including grounding details and material specifications to the authority having jurisdiction. Indicate approval of installation by authority having jurisdiction.

1.5 QUALIFICATIONS
A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

1.6 REGULATORY REQUIREMENTS
A. Conform to requirements of local electrical code.
B. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for the purpose specified and indicated.

1.7 COORDINATION
A. Coordinate under provisions of the General Requirements and Section 16010.

PART 2 – PRODUCTS

2.1 GROUNDING SYSTEM
A. Description: Complete grounding system of ground ring and rod electrodes, with connections to metal underground water pipe and building frame.
B. Grounding System Resistance: 1-5 ohms.

2.2 ROD ELECTRODES

A. Manufacturers:
   1. Harger Lightning Protection, Inc.
   2. Thompson Lightning Protection, Inc.
   3. Independent Protection Co., Inc.
B. Material: Copper.
C. Diameter: ¾-inch.
D. Length: 10 feet.

2.3 MECHANICAL CONNECTORS

A. Manufacturers:
   1. Appleton.
   2. OZ/Gedney.
   3. Thomas & Betts.
   4. Harger Lightning Protection, Inc.
   5. Thompson Lightning Protection, Inc.
   6. Independent Protection Co., Inc.
B. Material: Bronze.

2.4 WIRE

A. Material: Stranded copper.
B. Grounding Electrode Conductor: Size to meet local code requirements.
C. Grounding Conductors: Size to meet electrical code requirements. Green insulated, 600 volt minimum, stranded copper within raceway.

2.5 GROUNDING BUSHINGS

A. Manufacturers:
   1. Appleton GIB-50L.
   2. OZ/Gedney IBC-50L.
   3. Thomas & Betts 3870.
B. Material: Malleable iron, threaded, with insulated liner and solderless lug.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Verify conditions under provisions of the General Requirement Specification Sections.
B. Verify that final backfill and compaction has been completed before driving rod electrodes.

3.2 INSTALLATION

A. Install rod electrodes at locations indicated. Install additional rod electrodes as required to achieve specified resistance to ground. Drive rod electrodes into permanent moister where soil conditions permit. Rod spacing shall be minimum two and one-half rod lengths to nearest electrode.
B. Install bare copper wire in foundation footing where indicated.
C. Provide grounding electrode conductor and connect to reinforcing steel in foundation footing where indicated.
D. Provide bonding to meet Regulatory Requirements.
E. Bond together metal components including supports, elevator rails, pipes, and ducts not attached to grounded structure.
F. Provide isolated grounding conductor for circuits as indicated.

G. Provide a separate ground conductor in each feeder and branch circuit wiring.
   1. The Equipotential Grounding System shall consist of grounding and bonding conductors connected to ground bars arranged to minimize potential differences between exposed conductive surfaces of electrical and non-electrical equipment.
   2. All bonding and grounding conductors shall be installed in one continuous length, without splice, to ground bar.
   3. Minimum size:
      a) No. 12 AWG to receptacles, light switches, and light fixtures.
H. Equipment Ground Bus: Provide ground bus within each switchboard, motor control center, and panelboard.
I. Isolated Ground Bus: Provide ground bus insulated from enclosure within panelboards as indicated.
J. Equipment Grounding Conductor: Provide separate, insulated conductor within each feeder and branch circuit raceway. Terminate each end on suitable lug, bus, or bushing.
K. Flexible Conduit Connections: Provide separate, insulated ground bonding-jumper conductor within each flexible conduit.
L. Interface with site grounding system installed under the General Requirement Specification Sections.
M. Bond together metal sides not attached to grounded structure; bond to ground.
N. Bond together reinforcing sheet and metal accessories in pool and fountain structures.
O. Install transient suppression plate where indicated.
P. Install ground grid under access floors where indicated. Construct bare copper wire grid and bond each access floor pedestal to grid.
Q. Bond together each metallic raceway, pipe, duct and other metal object entering space under access floors. Bond to underfloor ground grid.
R. Provide isolated grounding conductor for circuits as indicated.
S. Provide grounding and bonding in patient care areas to meet requirements of NFPA 99 and local electrical code.
T. Provide grounding and bonding in data processing areas to meet requirements of local electrical code.
U. Interface with lightning protection system installed under Section 16670.
V. Provide red plastic sign at main water service meter indicating “main ground location”.

END OF SECTION

SECTION 16180

EQUIPMENT WIRING

PART 1 – GENERAL

1.1 SECTION INCLUDES
A. Electrical connections to equipment.

1.2 RELATED SECTIONS
A. Section 16111 - Conduit.
B. Section 16123 - Building Wire and Cable.
C. Section 16130 - Boxes.

1.3 REFERENCES
A. Section 01090 - Reference Standards: Requirements for references and standards.
B. NEMA WD 1 - General Purpose Wiring Devices.
C. NEMA WD 6 - Wiring Devices - Dimensional Requirements.
D. NFPA 70 - National Electrical Code.

1.4 SUBMITTALS FOR REVIEW
A. Submit under provisions of the General Requirements.

1.5 SUBMITTALS FOR INFORMATION
A. Submit under provisions of the General Requirements.

1.6 REGULATORY REQUIREMENTS
A. Conform to requirements of local electrical code.
B. Products: Listed and classified by Underwriters Laboratories, Inc. as suitable for the purpose specified and indicated.

1.7 COORDINATION
A. Section 16010 - Basic Electrical Requirements.
B. Obtain and review shop drawings, product data, manufacturer's wiring diagrams, and manufacturer's instructions for equipment furnished under other sections.
C. Determine connection locations and requirements.
D. Sequence rough-in of electrical connections to coordinate with installation of equipment.
E. Sequence electrical connections to coordinate with start-up of equipment.

PART 2 – PRODUCTS

Not Used.

PART 3 – EXECUTION

3.1 EXAMINATION
A. Section 16010 - Basic Electrical Requirements: Verification of existing conditions prior to beginning work.
B. Verify that equipment is ready for electrical connection, wiring, and energization.

3.2 ELECTRICAL CONNECTIONS

A. Make electrical connections in accordance with equipment manufacturer's instructions.
B. Make conduit connections to equipment using flexible conduit. Use Liquidtight flexible conduit with watertight connectors in damp or wet locations.
C. Connect heat producing equipment using wire and cable with insulation suitable for temperatures encountered.
D. Provide receptacle outlet to match attachment plug.
E. Provide cord and cap where field-supplied attachment plug is required.
F. Install suitable strain-relief clamps and fittings for cord connections at outlet boxes and equipment connection boxes.
G. Install disconnect switches, controllers, control stations, and control devices to complete equipment wiring requirements.
H. Install terminal block jumpers to complete equipment wiring requirements.
I. Install interconnecting conduit and wiring between devices and equipment to complete equipment wiring requirements.
J. Seal roof penetrations properly and as recommended by roofing manufacturer.

3.3 MECHANICAL EQUIPMENT SCHEDULE

A. As soon as practical and before any material or equipment is purchased or installed, the contractor shall submit for review, the mechanical equipment connection schedule for all mechanical equipment, completely filled in. The mechanical contractor shall stamp the mechanical equipment schedule to certify that he has coordinated and reviewed it. Any material or equipment installed without stamped or written approval of the mechanical equipment connection schedule shall be removed, modified or otherwise corrected at no additional cost to the Owner.
B. The schedule below is a sample of what is to be submitted.

MECHANICAL EQUIPMENT CONNECTION SCHEDULE						
EQUIPMENT DESIGNATION TAG	LOAD			BREAKER SIZE	FUSE SIZE	CONDUIT AND WIRE SIZE
	VOLTS	PHASE	H.P.			
AIR SUPPLY UNIT						
ROOF TOP UNIT						
AIR COOLED CONDENSING UNIT						
CHILLER						
HOT WATER BOILER						
HOT WATER PUMP						
BOILER CIRCULATION PUMP						
CHILLED WATER PUMP						
COIL BOOSTER PUMP						
SINGLE PHASE EXHAUST FANS						
THREE PHASE EXHAUST FANS						
FAN POWERED BOX						
CABINET UNIT HEATER						

SUSPENDED UNIT HEATER						
UNIT VENTILATOR						
FIRE PUMP						
JOCKEY PUMP						
DOMESTIC WATER PUMP						
KITCHEN MAKE-UP UNIT						
ELEVATOR						
DECK ELEVATOR						
ALL GYM EQUIPMENT						

END OF SECTION

SECTION 16190

SUPPORTING DEVICES

PART 1 – GENERAL

1.1 RELATED DOCUMENTS
A. The General Provisions of the Contract, including Conditions of the Contract and the General Requirement Specifications, apply to the work in this Section.
B. This Section is hereby made a part of all other sections of Division 16 as fully as if repeated in each therein.

1.2 SECTION INCLUDES
A. Conduit and equipment supports.
B. Anchors and fasteners.
C. Vibration Isolation.
D. Equipment Bases.

1.3 RELATED SECTIONS.
A. Section 16170 - Grounding and Bonding.

1.4 REFERENCES
A. NECA - National Electrical Contractors Association.
B. National Electrical Code.

1.5 SUBMITTALS
A. Submit under provisions of the General Requirements and Section 16010.
B. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, and installation of Product.

1.6 QUALIFICATIONS
A. Manufacturer: Company specializing in manufacturing Products specified in this Section with minimum three years' experience.

1.7 REGULATORY REQUIREMENTS
A. Conform to requirements of local electrical code, unless otherwise specified.
B. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for the purpose specified and indicated.

1.8 COORDINATION
A. Coordinate under provisions of the General Requirement Specification Sections and Section 16010.

PART 2 – PRODUCTS

2.1 PRODUCT REQUIREMENTS
A. Materials and Finishes: Provide adequate corrosion resistance.
B. Provide materials, sizes, and types of anchors, fasteners and supports to carry the loads of equipment and conduit. Consider weight of wire in conduit when selecting products. Design of supports and methods of fastening to building structures shall be acceptable to the Architect/Engineer.
C. Anchors and Fasteners: For point of attachment weight of 100 pounds or less.
    1. Concrete Structural Elements: Use precast insert system, expansion anchors, and preset inserts.
    2. Steel Structural Elements: Use beam clamps.
    3. Concrete Surfaces: Use self-drilling anchors and expansion anchors.
    4. Hollow Masonry, Plaster, and Gypsum Board Partitions: Use toggle bolts.

5. Solid Masonry Walls: Use expansion anchors and preset inserts.
6. Sheet Metal: Use sheet metal screws.
7. Wood Elements: Use wood screws.

D. Anchors and Fasteners: For point of attachment weight of 100 pounds or more, obtain direction and approval from Architect/Engineer.

2.2 STEEL CHANNEL

A. Manufacturer:
1. B-Line.
2. Unistrut.
3. Allied.

B. Description: Galvanized steel.

2.3 VIBRATION ISOLATION

A. Suspended vibration producing equipment shall have spring elements in the hanger rods or isolation pads under the equipment.

2.4 EQUIPMENT BASES

A. Provide 4" high concrete pads for floor mounted electrical equipment. The edge of the concrete pads shall have ¼" chamfer. The pad dimensions shall be at least one inch greater on each side than the floor dimensions of the electrical equipment.

B. Concrete pads shall include steel reinforcing and necessary bolts, anchors, etc. Where concrete pad is set directly on concrete floor, dowels in floor to tie base to floor shall be provided.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install products in accordance with manufacturer's instructions.
B. Provide anchors, fasteners, and supports in accordance with NECA "Standard of Installation".
C. Do not fasten supports to pipes, ducts, mechanical equipment, and conduit.
D. Do not use ceiling system components for support.
E. Connections to vibration producing equipment shall be made with flexible conduit.
F. Obtain permission from Architect/Engineer before using spring steel clamps.
G. Obtain permission from Architect/Engineer before using powder actuated anchors.
H. Obtain permission from Architect/Engineer before drilling or cutting structural members.
I. Fabricate supports from structural steel or steel channel. Rigidly weld members or use hexagon head bolts to present neat appearance with adequate strength and rigidity. Use spring lock washers under all nuts.
J. Install surface mounted cabinets and panelboards with minimum of four anchors.
K. In wet and damp locations use steel channel supports to stand cabinets and panelboards one inch off wall.
L. Use sheet metal channel to bridge studs above and below cabinets and panelboards recessed in hollow partitions.
M. Support surface or pendant lighting fixtures:
1. From an outlet box by means of an interposed metal strap, where weight is less than 5 pounds.
2. From an outlet box by means of a hickey or other direct threaded connection, where weight is from 5 to 50 pounds.
3. Directly from structural slab, deck, or framing member, where weight exceeds 50 pounds.

N. Support Recessed Lighting Fixtures:
1. From ceiling suspension members, where weight is less than 60 pounds.
2. Directly from structural slab, deck, or framing member, where weight is 60 pounds or more.

O. Provide cushioned, swivel type hangers with appropriate outlet boxes for pendant fixtures in mechanical areas. Such hangers shall have a support rating at least twice that of the load supported.
P. Provide weight distributing facilities, where required, so as not to exceed the load bearing capabilities of floors or walls that bear the weight of, or support, electrical items.
Q. Exposed parts of hangers and supports shall be painted with one coat of rust inhibiting primer.
R. Equipment shall not be held in place by its own dead weight. Provide base anchor fasteners in each case.
S. Vertical raceway shall be supported with spring type hangers.

END OF SECTION

SECTION 16195

ELECTRICAL IDENTIFICATION

PART 1 – GENERAL

1.1 RELATED DOCUMENTS
A. The General Provisions of the Contract, including Conditions of the Contract and the General Requirement Specifications, apply to the work in this Section.
B. This Section is hereby made a part of all other sections of Division 16 as fully as if repeated in each therein.

1.2 SECTION INCLUDES
A. Nameplates and labels.
B. Wire and cable markers.
C. Conduit and Pullbox markers.
D. Directories.
E. Signs and Diagrams.

1.3 RELATED SECTIONS
A. Division 09 - Painting.

1.4 REFERENCES
A. National Electrical Code.

1.5 SUBMITTALS
A. Submit under provisions of the General Requirements and Section 16010.
B. Product Data: Provide for nameplates, labels, and markers.
C. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency specified under regulatory requirements. Include instructions for storage, handling, protection, examination, preparation and installation of Product.

1.6 REGULATORY REQUIREMENTS
A. Conform to requirements of local electrical code, unless otherwise specified.
B. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for the purpose specified and indicated.

PART 2 – PRODUCTS

2.1 NAMEPLATES
A. Normal System Nameplates: Engraved three-layer laminated plastic, black letters on white background, identification as shown.
   1. Size: 1¼-inch by 3-inch minimum.
   2. Location: Each normal electrical distribution and control equipment enclosure: switchboards, motor control centers, panelboards, transformers, motor starters, disconnect switches, circuit breakers, contactors, relay panels, control panels, Cable TV, and associated apparatus. Communications control cabinets.
B. Letter Size:
   1. Use 3/16-inch height lettering for identifying equipment and loads.
C. Identification: Engraving marking.
   1. Switchboard, distribution panel: Equipment name and load device names.
   2. Branch circuit panelboard, relay panel, control panel, control cabinet: name.
   3. Transformer: name, primary and secondary voltage, service from.
   4. Motor starter, disconnect switch, individual circuit breaker, contactor: name, equipment served, service from.

2.2 LABELS

A. Labels: Engraved device plates for individual wall switches, receptacles, and other electrical devices as shown.
B. Locations: special purpose switches, receptacles, and other electrical devices.
C. Identification: Engraved device covers.
   1. Individual switches and receptacles: use or as indicated on drawings.
   2. 480 Volt System: 480

2.3 WIRE AND CABLE MARKERS

A. Description: Tape type wire markers.
B. Locations: Each conductor at panelboard gutters, pull boxes, and each load connection.
C. Legend:
   1. Power and Lighting Circuits: Branch circuit or feeder number indicated on drawings.
D. Color: - As indicated in Section 16123.

2.4 BUS IDENTIFICATION

A. Description: Stamped phase identification letters.
B. Location: Switchboard, motor control center, and panelboard bus, in readily visible locations.

2.5 CONDUIT MARKERS

A. Description: Alkyd stenciled paint.
B. Location: Each power conduit, except branch lighting and receptacle conduits, longer than 6 feet.
C. Spacing: At intermediate pull boxes, enclosures, etc.
D. Legend:
   1. 208 Volt System: 208 – panel name – panel number.
   2. 480 Volt System: 480 – panel name – panel number.

2.6 FEEDER INTERMEDIATED BOX MARKERS

A. Description: Alkyd stenciled paint.
B. Location: On pull box, splice box, and junction box covers.
C. Color:
   1. Grounding System: Green cover.
   2. Fire Alarm System: Red cover.

2.7 PANELBOARD DIRECTORIES

A. Description: Type written directory of branch circuit loads.
B. Location: At branch circuit panelboards.
C. Legend: circuit number - load location and description.

PART 3 – EXECUTION

3.1 PREPARATION

A. De-grease and clean surfaces to receive nameplates and labels.

3.2 APPLICATION

A. Install nameplate and label parallel to equipment lines.
B. Secure nameplate to equipment front using screws or rivets.
C. Secure nameplate to inside surface of door on panelboard that is recessed in finished locations.

END OF SECTION

SECTION 16426

SWITCHBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section Includes:
   1. Service and distribution switchboards rated 600 V and less.
   2. Disconnecting and overcurrent protective devices.
   3. Instrumentation.
   4. Accessory components and features.
   5. Identification.

1.3 ACTION SUBMITTALS

A. Product Data: For each switchboard, overcurrent protective device, surge protection device, ground-fault protector, accessory, and component.
   1. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

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. Detail enclosure types for types other than NEMA 250, Type 1.
   3. Detail bus configuration, current, and voltage ratings.
   4. Detail short-circuit current rating of switchboards and overcurrent protective devices.
   5. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.
   6. Detail utility company's metering provisions with indication of approval by utility company.
   7. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
   8. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.
   9. Include schematic and wiring diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. Field Quality-Control Reports:
   1. Test procedures used.
   2. Test results that comply with requirements.
   3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals.
   1. In addition to items specified in Section 01 7823 "Operation and Maintenance Data," include the following:
      a. Routine maintenance requirements for switchboards and all installed components.
      b. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
      c. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

1.6 FIELD CONDITIONS

A. Installation Pathway: Remove and replace access doors, lift-out panels, and structures to provide pathway for moving switchboards into place.
B. Environmental Limitations:
   1. Do not deliver or install switchboards until spaces are complete and dry, and work above switchboards is complete.
   2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
      a. Ambient Temperature: Not exceeding 104-degrees F.
      b. Altitude: Not exceeding 6600 feet.

1.7 COORDINATION

A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces.
B. Maintain required workspace clearances and required clearances for equipment access doors and panels.
C. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchorbolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.8 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace switchboard enclosures, buswork, overcurrent protective devices, accessories, and factory installed interconnection wiring that fail in materials or workmanship within specified warranty period.
   1. Warranty Period: Three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 SWITCHBOARDS

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Siemens Power Transmission & Distribution, Inc.
   2. No substitutions.
B. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
C. All panelboards, switchboards, circuit breakers, dry type transformers and disconnect switches shall be of the same manufacturer.
D. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
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.
F. Comply with NFPA 70.
G. Comply with UL 891.
H. Front-Connected, Front-Accessible Switchboards:
   1. Main Devices: Panel or Fixed, individually mounted.
   2. Branch Devices: Panel mounted.
   3. Sections front and rear aligned.
I. Indoor Enclosures: Steel, NEMA 250, Type 1.
J. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.
K. Service Entrance Rating: Switchboards intended for use as service entrance equipment shall contain from one to six service disconnecting means with overcurrent protection, a neutral bus with disconnecting link, a grounding electrode conductor terminal, and a main bonding jumper.

L. Utility Metering Compartment: Barrier compartment and section complying with utility company's requirements; hinged sealable door; buses provisioned for mounting utility company's current transformers and potential transformers or potential taps as required by utility company. If separate vertical section is required for utility metering, match and align with basic switchboard. Provide service entrance label and necessary applicable service entrance features.

M. Buses and Connections: Three phase, four-wire unless otherwise indicated.
   1. Provide phase bus arrangement A, B, C from front to back, top to bottom, and left to right when viewed from the front of the switchboard.
   2. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity,
   3. Copper feeder circuit-breaker line connections.
   4. Load Terminals: Insulated, rigidly braced, runback bus extensions, of same material as through buses, equipped with mechanical or compression connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full-ampere rating of circuit-breaker position.
   5. Ground Bus: Minimum-size required by UL 891, hard-drawn copper of 98 percent conductivity, equipped with mechanical or compression connectors for feeder and branch-circuit ground conductors.
   6. Main-Phase Buses and Equipment-Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
   7. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical or compression connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.

N. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

2.2 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 Shunt Trip 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. Provide arc reduction switch (Siemens Dynamic Arc Sentry – DAS) for circuit-breaker frame sizes 1200A and larger.

2.3 INSTRUMENTATION

A. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:
   1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:
      a. Phase Currents, Each Phase: Plus or minus 0.5 percent.
      b. Phase-to-Phase Voltages, Three Phase: Plus or minus 0.5 percent.
      c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 0.5 percent.
      d. Megawatts: Plus or minus 1 percent.
      e. Megavars: Plus or minus 1 percent.
      f. Power Factor: Plus or minus 1 percent.
      g. Frequency: Plus or minus 0.1 percent.
      h. Accumulated Energy, Megawatt Hours: Plus or minus 1 percent; accumulated values unaffected by power outages up to 72 hours.
      i. Megawatt Demand: Plus or minus 1 percent; demand interval programmable from five to 60 minutes.
      j. Contact devices to operate remote impulse-totalizing demand meter.
   2. Mounting: Display and control unit flush or semi-flush mounted in instrument compartment door.
   3. Sag/swell monitoring and voltage disturbance direction detection.

B. Phase Failure Relay: provide integral Taylor Electronics Phase Guard Model PND with reset delay function.

2.4 IDENTIFICATION

A. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

2.5 TRANSIENT VOLTAGE SURGE SUPPRESSION (TVSS)

A. Service Entrance – SPD shall be factory installed integral to electrical distribution equipment, and it shall be UL 1449 labeled as Type 2, verifiable at UL.com, without need for external or supplemental overcurrent controls. Every suppression component of every mode, including N-G, shall be protected by internal overcurrent and thermal over-temperature controls. SPDs relying upon external or supplementary installed safety disconnectors do not meet the intent of this specification.

1. SPD shall be UL labeled with 20kA I-normal (L-N) (verifiable at UL.com) as recommended for UL 96A Lightning Protection Master Labeling and NFPA 780. SPD shall be UL labeled with 200kA Short Circuit Current Rating (SCCR).
2. SPD shall provide surge current paths for all modes of protection: L-N, L-G, L-L, and N-G for Wye systems; L-L, L-G in Delta and impedance grounded Wye systems.
3. SPD shall be connected to the buss of the distribution equipment wit an appropriately sized 200kA SCCR rated disconnect.
4. SPD shall meet or exceed the following criteria:
   a. Maximum surge current capability shall be 300kA per phase.
   b. UL 1449 – Fourth Edition Revision; effective March 26, 2015 Voltage Protection Ratings shall not exceed the following:

VOLTAGE	L-N	L-G	N-G	L-L	MCOV
208Y/120	700V	700V	700V	1200V	150V
480Y/277	1200V	1200V	1200V	2000V	320V

5. UL 1449 Listed Maximum Continuous Operating Voltage (MCOV) (verifiable at UL.com):

System Voltage	Allowable System Voltage Fluctuation (%)	MCOV
208Y/120	25%	150V
480Y/277	15%	320V

6. SPD shall incorporate a UL 1283 listed EMI/RFI filter with minimum attenuation of 50dB at 100 kHz.
7. Suppression components shall be heavy duty “large block” MOVs, each exceeding 30mm in diameter.
8. SPD shall include a serviceable, replaceable module.
9. SPD shall be equipped with the following diagnostics:
   a. Visual LED diagnostics including a minimum of one green LED indicator per phase, and one red service LED.
   b. Audible alarm with on/off silence function and diagnostic test function (excluding branch).
   c. Form C dry contacts.
   d. Surge Counter.
   e. No other test equipment shall be required for SPD monitoring or testing before or after installation.
10. SPD shall have a response time no greater than ½ nanosecond.
11. SPD shall have a 10-year warranty.”

PART 3 - EXECUTION

3.1 EXAMINATION

A. Panelboards:
   1. Lift or move panelboards with spreader bars and manufacturer-supplied lifting straps following manufacturer's instructions.
   2. Use rollers, slings, or other manufacturer-approved methods if lifting straps are not furnished.
   3. Protect from moisture, dust, dirt, and debris during storage and installation.
   4. Install temporary heating during storage per manufacturer's instructions.

B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.

C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work or that affect the performance of the equipment.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

A. Equipment Mounting: Install switchboards on concrete base, 4-inch nominal thickness.
   1. Install conduits entering underneath the switchboard, entering under the vertical section where the conductors will terminate. Install with couplings flush with the concrete base. Extend 2 inches above concrete base after switchboard is anchored in place.
   2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
   3. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
   4. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
   5. Install anchor bolts to elevations required for proper attachment to switchboards.
   6. Anchor switchboard to building structure at the top of the switchboard if required or recommended by the manufacturer.

B. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, straps and brackets, and temporary blocking of moving parts from switchboard units and components.

C. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures.

D. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.

E. Install filler plates in unused spaces of panel-mounted sections.

F. Install overcurrent protective devices, surge protection devices, and instrumentation.
   1. Set field-adjustable switches and circuit-breaker trip ranges.

3.3 CONNECTIONS

A. Comply with requirements for terminating feeder bus specified in Section 262500 "Enclosed Bus Assemblies." Drawings indicate general arrangement of bus, fittings, and specialties.

B. Bond conduits entering underneath the switchboard to the equipment ground bus with a bonding conductor sized per NFPA 70.

C. Support and secure conductors within the switchboard according to NFPA 70.

D. Extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.

3.4 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."

B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Section 26 0553 "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 Section 260 553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:
   1. Acceptance Testing:
      a. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit. Open control and metering circuits within the switchboard, and remove neutral connection to surge protection and other electronic devices prior to insulation test. Reconnect after test.
      b. Test continuity of each circuit.
   2. Test ground-fault protection of equipment for service equipment per NFPA 70.
   3. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
   4. Correct malfunctioning units on-site where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
   5. Perform the following infrared scan tests and inspections, and prepare reports:
      a. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
B. Switchboard will be considered defective if it does not pass tests and inspections.
C. 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.

3.6 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

3.7 DEMONSTRATION

A. Provide written documentation of all set up parameters for digital electrical meters provided.

END OF SECTION

SECTION 16441

ENCLOSED SWITCHES

PART 1 – GENERAL

1.1 RELATED DOCUMENTS
A. The General Provisions of the Contract, including Conditions of the Contract and Division 01 of the Specifications, apply to the work in this Section.
B. This Section is hereby made a part of all other sections of Division 16 as fully as if repeated in each therein.

1.2 SECTION INCLUDES
A. Fusible switches.
B. Non-fusible switches.

1.3 RELATED SECTIONS
A. Section 16195 - Fuses.
B. Section 16477 - Electrical Identification.

1.4 REFERENCES
A. NECA - (National Electrical Contractors Association) Standard of Installation.
B. NEMA FU1 - Low Voltage Cartridge Fuses.
C. NEMA KS1 - Enclosed and Miscellaneous Distribution Equipment Switches (600 Volts Maximum).
D. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems (published by the International Electrical Testing Association).
E. Local electrical code.

1.5 SUBMITTALS
A. Submit under provisions of Division 01 Specification Sections and Section 16010.
B. Product Data: Provide for enclosed switches.
C. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, and installation of Product.
D. Project Record Documents: Record actual locations of enclosed switches in project record documents.

1.6 QUALIFICATIONS
A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years' experience.

1.7 REGULATORY REQUIREMENTS
A. Conform to requirements of local electrical code.
B. Furnish products listed and classified by Underwriters Laboratories, Inc. or suitable for the purpose specified and indicated.

1.8 COORDINATION
A. Coordinate under provisions of Division 01 Specification Sections and Section 16010.
B. Field Measurements: Verify that field measurements are as shown on Drawings.
C. Field Locations: Verify locations of transformers prior to rough in.

SECTION 16441

ENCLOSED SWITCHES

PART 2 – PRODUCTS

2.1 ENCLOSED SWITCHES

A. Manufactures:
   1. GE.
   2. Siemens ITE.
   3. No Substitutions.

2.2 FUSIBLE SWITCH ASSEMBLIES

A. Description: NEMA KS 1, Type HD (Heavy Duty) type, horsepower rated, with operable handle interlocked to prevent opening front cover with switch in ON position. Handle lockable in OFF position.
B. Fuse clips: Designed to accommodate NEMA FU1, Class R fuses only.

2.3 NONFUSIBLE SWITCH ASSEMBLIES

A. Description: NEMA KS 1, Type HD (Heavy Duty) type, horsepower rated, with externally operable handle interlocked to prevent opening front cover with switch in ON position.

2.4 ENCLOSURES

A. Description: Code gauge steel
B. Finish: Phosphate coated, primed and finished with high grade lacquer, manufacturers standard color.
C. Fabrication: NEMA KS 1.
   1. Indoor clean, dry locations: Type 1.
   2. Indoor dusty, dry locations: Type 12.
   3. Indoor wet locations: Type 4X.
   4. Outdoor locations: Type 3R – stainless-steel.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install in accordance with NECA "Standard of Installation."
B. Install fuses in fusible disconnect switches.
C. Apply adhesive tag on inside door of each fused switch indicating NEMA fuse class and size installed.
D. Apply Identification Tag.

3.2 CLEANING

A. Clean installed work under the provisions of Division 01 Specification Sections.
B. Clean interior of enclosures to remove dust, debris, and other material.
C. Clean surfaces and restore finish.

END OF SECTION

SECTION 16461

DRY TYPE TRANSFORMERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS
A. The General Provisions of the Contract, including Conditions of the Contract and Division 1 of the Specifications, apply to the work in this Section.
B. This Section is hereby made a part of all other sections of Division 16 as fully as if repeated in each therein.

1.2 SECTION INCLUDES
A. General purpose dry type two-winding transformers.

1.3 RELATED SECTIONS
A. Section 16170 - Grounding and Bonding.
B. Section 16190 - Supporting Devices.
C. Section 16195 - Electrical Identification.

1.4 REFERENCES
A. ANSI/IEEE C57.96 Distribution and Power Transformers, Guide for Loading Dry-Type (appendix to ANSI C57.12 standards).
B. ANSI/IEEE C89.2 – Dry Type Transformers for General Applications.
C. ANSI/NFPA 70, National Electrical Code.
D. IEEE C57.12.01, General Requirements for Dry-Type Distribution and Power Transformers including those with Solid Cast and/or Resin-Encapsulated Windings.
E. IEEE C57.12.91, Test Code for Dry-Type Distribution and Power Transformers.
F. NEMA ST 20, Dry Type Transformers for General Applications.
G. UL 506, Specialty Transformers.

1.5 SUBMITTALS
A. Submit under provisions of Division 1 and Section 16010.
B. Product Data: Provide outline and support point dimensions of enclosures and accessories, unit weight, voltage, kVA, and impedance ratings and characteristics, no-load and full-load losses, tap configurations, insulation system type, and rated temperature rise.
C. Test Reports: Indicate loss data, efficiency at 25, 50, 75 and 100 percent rated load, and sound level.
D. Manufactures Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, and installation of Product.
E. Project Record Documents: Record actual locations of transformers in project record documents.

1.6 QUALIFICATIONS
A. Manufacturer shall have specialized in the manufacture and assembly of dry type transformers for 10 years.
B. Dry type transformers shall be listed and/or classified by Underwriter Laboratories in accordance with standards listed in Article 1.03 of this specification.
C. Manufacturer’s Certificate of ISO 9000 Compliance.
D. Installers’ Certificate of ISO 9000 Compliance.

1.7 REGULATORY REQUIREMENTS
A. Conform to requirements of local electrical code, unless otherwise specified.
B. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for the purpose specified and indicated.

1.8 COORDINATION

A. Coordinate under provisions of Division 1 and Section 16010.
B. Field Measurements: Make all necessary field measurements to verify that equipment shall fit in allocated space in full compliance with minimum required clearances specified in applicable electrical code.
C. Field Locations: Verify locations of transformers prior to rough in.

1.9 DELIVERY, STORAGE, PROTECTION, AND HANDLING

A. Deliver, store, protect and handle products in accordance with recommended practices listed in manufacturer's Installation and Maintenance Manuals.
B. Each dry type transformer shall be mounted on shipping skids and wrapped for protection.
C. Inspect and report concealed damage to carrier within specified time.
D. Store in a clean, dry space. Maintain factory protection or cover with heavy canvas or plastic to keep out dirt, water, construction debris, and traffic. (Heat enclosure to prevent condensation).
E. Handle in accordance with NEMA and manufacturer's written instructions to avoid damaging equipment, installed devices and finish. Lift only by installed lifting eyes.

PART 2 - PART 2 – PRODUCTS

2.1 TWO-WINDING TRANSFORMERS

A. Manufacturers:
   1. GE.
   2. Siemens.
B. Description: NEMA TP-1 rated, energy efficient, factory assembled, air cooled dry type transformers, ratings as indicated.
C. Primary Voltage: 480 volts, 3-phase.
D. Secondary Voltage: 208Y/120 volts, 3-phase, 4-wire.
E. Insulation system and average winding temperature rise for rated kVA as follows:
   1. 1 15 kVA: Class 185 with 115 degrees C rise.
   2. 16 500 kVA: Class 220 with 115 degrees C rise.
F. Transformers shall use properly classified UL approved temperature ratings. Temperature rise ratings shall be in accordance with UL 506. Insulation ratings shall be as indicated in drawings.
G. Transformers supplied to this specification shall be able to operate continuously at 100 percent nameplate rating at ambient temperature not exceeding 40 degrees C. Maximum temperature at top of enclosure shall not exceed 50 degrees C rise above 40 degrees C. ambient.
H. Transformers 5 KVA and above shall be able to meet ANSI/IEEE C57.96 daily overload requirements listed in drawings. Transformers loaded in accordance with this paragraph shall be capable of long service life under thermal conditions specified. There shall be no need for derating.
I. Enclosures shall meet UL 506 requirements for the following characteristics:
   1. Ventilation Openings;
   2. Corrosion Resistance;
   3. Cable Bending Space;
   4. Surface Temperature Rise;
   5. Wiring Compartment Temperature Rise;
   6. Terminations.

J. Transformer Construction
   1. Transformer cores shall be constructed of high grade, non-aging silicon steel with high magnetic permeability and low hysteresis and eddy current losses. Magnetic flux densities shall be kept well below core saturation point. Core lamination above 112.5 KVA shall be miter cut at core corners to reduce hot spots, core loss, current and sound level. Core lamination shall be clamped together with steel angles. Cores for transformers above 300 KVA shall be clamped using insulated bolts through core laminations to provide proper pressure throughout core length. Completed core and coil shall be bolted to enclosure base and isolated from base by rubber vibration-absorbing mounts. There shall be no metal-to-metal contact between core and coil and enclosure. Sound isolation systems requiring complete removal of all fastening devices is not acceptable.
   2. Transformer core shall be visibly grounded to enclosure by flexible grounding conductor meeting UL and NEC size requirements.
   3. Enclosure shall be constructed of heavy gauge steel.
   4. All coils and bus bars shall be copper.

K. Basic Impulse Level: 10 kV for transformers less than 300 kVA, 30 kV for transformers 300 kVA and larger.

L. Ground core and coil assembly to enclosure by means of a visible flexible copper grounding strap.

M. Mounting:
   1. 1-15 kVA: Suitable for wall mounting.
   2. 16-75 kVA: Suitable for wall, floor, or trapeze mounting.
   3. Larger than 75 kVA: Suitable for floor or trapeze mounting.

N. Coil Conductors: Continuous copper windings with terminations brazed or welded. The coils shall include a final insulating wrap to prevent mechanical injury to the coil as well as increase the coil electrical breakdown strength.

O. Cores: High grade, high strength, non-aging steel with high magnetic permeability and low hysteresis and eddy current losses.

P. Enclosure: NEMA ST 20, Type 1 non-ventilated. Provide lifting eyes or brackets. Grey baked enamel finish.

Q. Isolate core and coil from enclosure using rubber vibration absorbing mounts.

R. Nameplate: Include transformer connection data and overload capacity based on rated allowable temperature rise.

2.2 LOAD TAPS

A. Transformers shall have following high voltage load tap arrangements unless noted otherwise in plans:
   1. Through 2 KVA – no taps;
   2. Through 23 KVA – no taps;
   3. 3 through 35 KVA – 4, 2-1/2 percent taps, 2 above, 2 below nominal voltage.
   4. Through 500 KVA – 6, 2-1/2 percent taps, 2 above, 4 below nominal voltage.
   5. 750 KVA – 4, 3.1 percent taps, 2 above, 2 below nominal voltage.
   6. 1000 KVA – 2, 3.6 percent taps, 1 above, 1 below nominal voltage.

2.3 TESTING

A. Transformers furnished to this specification shall receive the following production tests, per NEMA ST 20.
   1. Applied potential.
   2. Induced potential.
   3. No load losses.
   4. Voltage ratio.
   5. Polarity.
   6. Continuity.

B. Manufacturer shall perform the following additional tests on units identical to the design type being supplied to this specification. Manufacturer shall provide on request test data sheets to prove performance of these tests.
   1. Sound levels.
   2. Temperature rise tests.
   3. Full-load loses.
   4. Regulation.
   5. Impedance.

2.4 FINISH

A. Finish shall consist of degreasing, phosphate cleaning, and an electrodeposit ANSI 61 gray enamel paint.

PART 3 - PART 3 – EXECUTION

3.1 PREPARATION

A. Provide concrete equipment base for floor mounted equipment installation.

3.2 INSTALLATION

A. Set transformer plumb and level.
B. Use flexible conduit, under the provisions of Section 16111, 2 feet minimum length, for connections to transformer case. Make conduit connections to side panel of enclosure.
C. Provide grounding and bonding in accordance with Section 16170.
D. Install per manufacturer’s instructions.

3.3 ADJUSTING

A. Adjust installed work under provisions of Division 1 General Requirements.
B. Measure primary and secondary voltages and make appropriate tap adjustments.

3.4 FIELD QUALITY CONTROL

A. Inspect installed dry type transformers for anchoring, alignment, grounding and physical damage.
B. Check tightness of all accessible mechanical and electrical connections with calibrated torque wrench. Minimum acceptable values are specified in manufacturer’s instructions.

3.5 CLEANING

A. Repaint scratched or marred exterior surfaces to match original finish.

END OF SECTION

SECTION 16470

PANELBOARDS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS
A. The General Provisions of the Contract, including Conditions of the Contract and the General Requirement Specifications, apply to the work in this Section.
B. This Section is hereby made a part of all other sections of Division 16 as fully as if repeated in each therein.

1.2 SECTION INCLUDES
A. Power panelboards.
B. Branch circuit panelboards.

1.3 RELATED SECTIONS
A. Section 16170 - Grounding and Bonding.
B. Section 16195 - Electrical Identification.
C. Section 16475 - Transient Voltage Surge Suppression.

1.4 DEFINITIONS
A. Lighting and Appliance Panelboard: A panelboard with thermal magnetic circuit breaker branches, bolt-on type only, designed for heavy commercial use, operating at 600 V and below, 3-phase versions, equipped as either surface or flush mounting. Panelboard shall have more than 10% of its overcurrent devices rated 30 amperes or less for which neutral connections are provided.
B. Power Panelboard: A panelboard with thermal magnetic circuit breakers or fusible switches, bolt-in type, designed for heavy commercial use, operating at 600V and below, 3-phase version, equipped as surface mounting with cabled connections between sections. Panelboard shall have less than 10% of its concurrent devices rated 30 amperes or less for which neutral connections are provided.
C. Overcurrent Protective Devices – a circuit breaker pole or single fuse. Example: a 2-pole device is considered 2 protective devices.

1.5 REFERENCES
A. ANSI 61.
B. ANSI/NEMA KS 1, Enclosed and Miscellaneous Distribution Equipment Switches (600 volts).
C. ANSI/NEMA PB 1, Panelboards.
D. ANSI/NFPA 70, National Electrical Code.
E. ASTM – American Society of Testing Materials.
F. CSA C22.2 No. 29, Panelboards and Enclosed Panelboards.
G. CSA C22.2 No. 5.1, Molded Case Circuit Breakers.
H. Federal Specification W-C-375, Rev. B, Amend. 1, Circuit Breakers, Molded Case; Branch Circuit and Service.
I. Federal Specification W-P 115, Rev. C, Panel, Power Distribution.
J. NEMA AB1, Molded Case Circuit Breakers and Molded Case Switches.
K. NEMA PB 1.1, General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.
L. UL 489, Molded-Case Circuit Breakers and Circuit-Breaker Enclosures.
M. UL 50, Enclosures for Electrical Equipment.
N. UL 67, Panelboards.
O. UL 943, Ground-Fault Circuit-Interrupters.

1.6 SUBMITTALS
A. Submit under provisions of the General Requirements and Section 16010.
B. Product Data: Provide for fusible switches and circuit breakers.
C. Shop Drawings: Indicate outline and support point dimensions, voltage, main bus ampacity, short circuit ampere rating, circuit breaker and fusible switch arrangement and sizes.

D. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, and installation of Product.
E. Project Record Documents: Record actual locations of panelboards and record actual circuiting arrangements in project record documents.
F. Maintenance Data: Include spare parts listing; source and current prices of replacement parts and supplies; and recommended maintenance procedures and intervals.

1.7 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum twenty years' experience.

1.8 REGULATORY REQUIREMENTS

A. Conform to requirements of NFPA 70, unless otherwise specified.
B. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for the purpose specified and indicated.

1.9 COORDINATION

A. Coordinate under provisions of the General Requirements and Section 16010.
B. Field Measurements: Verify that field measurements are as shown on Drawings.
C. Field Locations: Verify locations of panelboards prior to rough in.

1.10 DELIVERY, STORAGE, PROTECTION, AND HANDLING

A. Deliver, store, protect and handle products in accordance with recommended practices in manufacturer's Installation and Maintenance Manuals.
B. Deliver each lighting panelboard in individual shipping cases for ease of handling. Each panelboard shall be wrapped for protection.
C. Inspect and report concealed damage to carrier within specified time.
D. Store in a clean, dry space. Maintain factory protective or cover with heavy canvas or plastic to keep out dirt, water, construction debris, and traffic. (Heat enclosures to prevent condensation).
E. Handle in accordance with NEMA and manufacturer's written instructions to avoid damaging equipment, installed devices and finish.

1.11 OPERATION AND MAINTENANCE DATA

A. Manufacturer shall provide copies of installation, operation and maintenance procedures to Owner in accordance with general requirements of the General Requirements and Division 16.
B. Submit operation and maintenance data based on factory and field testing, operation and maintenance of specified product.

1.12 FIELD MEASUREMENTS

A. Make all necessary field measurements to verify that equipment shall fit in allocated space in full compliance with minimum required clearances specified in National Electrical Code.

PART 2 – PRODUCTS

2.1 PANELBOARDS

A. Phase sequence and balance.
   1. Phase sequence: A-B-C, left to right.
   2. Load balance: Distribute loads for maximum 10 percent difference.
B. Each panelboard, and associated fused switches and circuit breakers, shall be of the same manufacturer.
C. Each panelboard lock shall be operable by the same key.

D. Panelboard Manufacturers: ITE/Siemens products have been used as the basis for design. The following other manufacturers' products of equivalent quality, dimensions and operating features may be acceptable, at the Engineer's discretion, if they comply with all requirements specified or indicated in these Contract documents.
   1. ITE/Siemens
   2. No Substitutions.
E. Fused Switch and Circuit Breaker Manufacturers: Must match existing equipment.
   1. ITE/Siemens
   2. No Substitutions.

2.2 SWITCHBOARDS

2.3 DISTRIBUTION PANELBOARDS

A. Description: NEMA PB 1, circuit breaker or fusible switch type as shown on drawings. Provide contactors as indicated.
B. Panelboard Bus: 1000 amp per sq.in. Copper, ampere and voltage ratings as indicated. Provide copper ground bus in each panelboard.
C. Minimum Short Circuit Rating: Fully rated, 42,000 amperes rms symmetrical for 240 volt panelboards; 65,000 amperes rms symmetrical for 480 volt panelboards, or as indicated, or as required to be greater than the available short circuit current.
D. Molded Case Circuit Breakers: NEMA AB 1, circuit breakers with integral thermal and instantaneous magnetic trip in each pole. Provide circuit breakers UL listed as Type HACR for air conditioning equipment branch circuits. Quantity and ratings as indicated. Circuit breakers shall bolt directly onto bus, modular devices utilizing spring reinforcement jaws with pressure locked connections are not acceptable.
E. Controllers: NEMA ICS 2, AC general purpose Class A magnetic controller for induction motors rated in horsepower, with bimetal overload relay. Size and ratings as indicated. Provide unit mounted control power transformer and HAND-OFF-AUTO selector switch and GREEN indicating light in front cover.
F. Circuit Breaker Accessories: Trip units and auxiliary switches as indicated.
G. Enclosure: NEMA PB 1, Galvanized steel finished inside and outside with manufactures standard gray enamel, fully flanged, fastened with quarter-turn trim clamps. Type 1 or 12 or 3R as suitable for the location, 12 inches deep, 35 inches wide, minimum, or as required to accommodate the number of outgoing conduits.
H. Cabinet Front: Surface type, finished in manufacturer's standard gray enamel. Fasten doors 48 inches in height or less with concealed hinged door with flush catch lock. Fasten doors over 48 inches in height with three point catch lock and vault type handle.

2.4 BRANCH CIRCUIT PANELBOARDS

A. Equipment:
   1. Furnish ITE/Siemens Lighting Panelboards or equal as indicated in drawings.
   2. Minimum Short Circuit Rating: Fully rated, 22,000 amperes rms symmetrical for 240 volt panelboards; 22,000 amperes rms symmetrical for 480 volt panelboards, or as indicated, or as required to be greater than the available short circuit current.
B. Enclosure
   1. Boxes shall be a nominal 20 inches wide and 6 inches deep with wire bending space per local electrical code.
   2. Fronts shall be reinforced steel with concealed hinges and concealed trim adjusting screws. Trim clamps are unacceptable.
   3. All door locks shall be corrosion proof Valox (or equal) with retractable latches. All door locks shall be keyed for a single key.
   4. Clean Lexan (or equal) directory card holders shall be permanently mounted on front door.
   5. All panelboard series ratings shall be prominently displayed on dead front shield.

6. Interiors shall permit top or bottom incoming cables.
7. Boxes shall be corrosion resistant, zinc finish galvanized.
8. Fronts shall be powder finish painted ANSI G1 gray.

C. Bus bars
1. Bus bars shall be copper and phase sequenced, fully insulated and supported by high impact Noryl (or equal) interior base assemblies.
2. Panelboard Bus: 1000 amp per sq. in. Copper, ampere and voltage ratings as indicated. Provide copper ground bus in each panelboard. Provide insulated ground bus where identified. Provide 200% rated neutral where identified.
3. Bus bars shall be mechanically supported by zinc finished galvanneal steel frames to prevent vibration and damage from short circuits.
4. Terminations shall be UL tested and listed and suitable for UL copper wire.
5. Provide [1] continuous bus bar per phase. Each bus bar shall have sequentially phased branch circuit connectors for bolt-on branch circuit breakers. Bus bars shall be rated as indicated in drawings.
6. Split solid neural bus shall be plated and located in main compartment for all incoming neutral cables to be same length.
7. Lugs shall be rated for 75 degree C terminations.
8. Main lugs for copper conductors shall be bolted lugs.
9. Lug bodies shall bolt in place.

D. Circuit Breakers
1. Molded case circuit breakers shall be bolt-on type.
2. All circuit breakers shall have thermal and magnetic type elements in each pole.
3. Two and three pole breakers shall have internal common trip crossbars for simultaneous tripping of each pole.
4. Circuit breakers shall not be restricted to any mounting location due to physical size.
5. All branch breakers 15 to 100 amperes shall be able to be mounted in any panel position for twin or double mounting without space penalty. Sum of ratings for 2 such twin mounted devices shall not exceed 180 amperes.
6. Main and sub-feed circuit breakers may be vertically or horizontally mounted.
7. Branch breaker panelboard connections shall be copper to copper.
8. All panelboard terminations shall be rated as indicated in drawings.
9. All breakers shall have an over center mechanism and be quick make and quick break.
10. All breakers shall have handle trip indication and a trip indicator in window of circuit breaker housing.
11. Breaker handle and faceplate shall indicate rated ampacity.
12. Circuit breaker escutcheon shall have standard ON/OFF markings.
13. Main breakers shall be UL listed for use with: Shunt, Under Voltage, and Ground Fault Shunt Trips; Auxiliary and Alarm Switches; and Mechanical Lug Kits. Provide these accessories as indicated on drawings.
14. Where indicated on drawings, the branch circuit breakers shall be SWD type, type HACR for air-conditioning equipment, ground fault circuit interrupter type, arc fault circuit interrupter type and shall have shunt trip accessories.

E. Contactors
1. Contactors shall be mechanically held GE type CR160MC, or ASCO Type 920 or approved equal.

2.5 ACCESSORIES

A. Contactor control relays.
B. Tork (or equal) time clocks.
C. Locking devices for breakers and/or operating handles.
D. Furnish nameplates for each device as indicated in drawings.
E. Provide Transient Voltage Surge Suppression system as specified.

PART 3 – EXECUTION

3.1 PREPARATION

A. Provide concrete equipment base for floor mounted equipment installation.
B. Verify field measurements.
C. Verify that required utilities are available, in proper location and ready for use.
D. Beginning of installation means installer accepts conditions.

3.2 INSTALLATION

A. Install panelboards in accordance with NEMA and NECA standards and as instructed by manufacturer.
B. Install panelboards plumb. Install recessed panelboards flush with wall finishes.
C. Support free-standing panelboards with structural channel framework.
D. Height: 6 feet to top of panelboard; install panelboards taller than 6 feet with lowest operating handle not lower than 18” above finished floor per NEC.
E. Provide filler plates for unused spaces in panelboards.
F. Provide typed circuit directory for each branch circuit panelboard under the provisions of Section 260553. Revise directory to reflect circuiting changes required to balance phase loads.
G. Provide engraved plastic nameplates under the provisions of Section 16195.
H. Provide 3-3/4” spare conduits out of each recessed panelboard to an accessible location above ceiling. Identify each as SPARE.
I. Ground and bond panelboard enclosure according to Section 16170.
J. Inspect installed panelboards for anchoring, alignment, grounding and physical damage.
K. Check tightness of all accessible mechanical and electrical connections with calibrated torque wrench. Minimum acceptable values are specified in manufacturer’s instructions.
L. Test each key interlock system for proper functioning.

3.3 ADJUSTING

A. Measure steady state load currents at each panelboard feeder; rearrange circuits in the panelboard to balance the phase loads to within 10 percent of each other. Maintain proper phasing for multi wire branch circuits.
B. Adjust all circuit breakers, access doors, operating handles for free mechanical and/or electrical operation as described in manufacturer’s instructions.

3.4 CLEANING

A. Clean installed work under the provisions of the General Requirements.
B. Clean interior of cabinets and enclosures to remove dust, debris, and other material.
C. Clean surfaces and touch up scratched or marred surfaces to match original finish.

END OF SECTION

SECTION 16477

FUSES

PART 1 – GENERAL

1.1 RELATED DOCUMENTS
A. The General Provisions of the Contract, including Conditions of the Contract and the General Requirement Specifications, apply to the work in this Section.
B. This Section is hereby made a part of all other sections of Division 16 as fully as if repeated in each therein.

1.2 SECTION INCLUDES
A. Fuses.

1.3 REFERENCES
A. Local Electric Code.
B. NEMA FU 1 - Low Voltage Cartridge Fuses.

1.4 SUBMITTALS
A. Submit under provisions of Division 01 and Section 16010.
B. Product Data: Provide data sheets showing electrical characteristics including time current curves.
C. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, and installation of Product.
D. Project Record Documents: Record actual fuse sizes in project record documents.
E. Maintenance Data: Include spare parts listing; source and current prices of replacement parts and supplies; and recommended maintenance procedures and intervals.

1.5 QUALIFICATIONS
A. Manufacturer: Company specializing in manufacturing the products specified in this section with minimum three years' experience.

1.6 REGULATORY REQUIREMENTS
A. Conform to requirements of local electrical code.
B. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for the purpose specified and indicated.

1.7 COORDINATION
A. Coordinate under provisions of the General Requirements and Section 16010.

PART 2 – PRODUCTS

2.1 FUSES
A. Dimensions and Performance: NEMA FU 1, Class as specified or indicated.
B. Voltage: Provide fuses with voltage rating suitable for circuit phase to phase voltage.
C. Interrupting Rating: 200,000 rms amperes.
D. Coordination: Provide fuses for properly coordinated system of overcurrent protection.

2.2 MOTOR AND DRY TYPE TRANSFORMER LOAD FUSES

A. Description: 600 amperes and smaller, 250 volts or less, Class RK5.
   1. Manufacturers (RK5):
      a. Bussmann Fusetron FRN-R
      b. Gould Shawmut.
B. Description: 601 amperes and larger, 250 volts or less, Class L.
   1. Manufacturers (L):
      a. Bussmann KRP-C
      b. Gould Shawmut
C. Description: 600 amperes and smaller, 600 volts or less, Class RK5.
   1. Manufacturers (RK5):
      a. Bussmann Fusetron FRS-R
      b. Gould Shawmut
   2. Manufacturers (J):
      a. Bussmann Low Peak LPJ
      b. Gould Shawmut
D. Description: 601 amperes and larger, 600 volts or less, Class L.
   1. Manufacturers (L):
      a. Bussmann KRP-C
      b. Gould Shawmut

2.3 LIGHTING AND HEATING LOAD FUSES

A. Description: 600 amperes and smaller, 250 volts or less, Class RK1, RK5.
   1. Manufacturers (RK5-time delay):
      a. Bussmann Fusetron FRN-R
      b. Gould Shawmut
   2. Manufacturers (J-time delay):
      a. Bussman LPJ
      b. Gould Shawmut
B. Description: 601 amperes and larger, 250 volts or less, Class L.
   1. Manufacturers (L-time delay):
      a. Bussmann KRP-C
      b. Gould Shawmut
   2. Manufacturers (L-non-time delay):
      a. Bussmann KTU
      b. Gould Shawmut
C. Description: 600 amperes and smaller, 600 volts or less, Class RK1, RK5.
   1. Manufacturers (RK1-time delay):
      a. Bussmann Low Peak LPS-RK
      b. Gould Shawmut
   2. Manufacturers (RK5-time delay):
      a. Bussmann Fusetron FRS-R
      b. Gould Shawmut
   3. Manufacturers (J-time delay):
      a. Bussmann LPJ
      b. Gould Shawmut
D. Description: 601 amperes and larger, 600 volts or less, Class L.
   1. Manufacturers (L-time delay):
      a. Bussmann KRP-C
      b. Gould Shawmut
   2. Manufacturers (L-non-time delay):
      a. Bussmann KTU
      b. Gould Shawmut

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install fuses in accordance with manufacturer's instructions.
B. Install fuse with label oriented such that manufacturer, type, and size are easily read.
C. Do not install parallel sets of fuses for any single phase.
D. Replace fuses blown during construction and during testing.

END OF SECTION

SECTION 16481

ENCLOSED MOTOR CONTROLLERS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS
A. The General Provisions of the Contract, including Conditions of the Contract and the General Requirement Specifications, apply to the work in this Section.
B. This Section is hereby made a part of all other sections of Division 16 as fully as if repeated in each therein.

1.2 SECTION INCLUDES
A. Manual motor starters.
B. Magnetic motor starters.
C. Combination magnetic motor starters.

1.3 RELATED SECTIONS
A. Section 16170 - Grounding and Bonding.
B. Section 16180 - Equipment Wiring Systems.
C. Section 16190 - Supporting Devices.
D. Section 16195 - Electrical Identification.
E. Section 16441 - Enclosed Switches.
F. Section 16477 - Fuses.

1.4 REFERENCES
A. NFPA 70 – Local Electrical Code.
B. CSA C22 No 14, Industrial Control Equipment.
C. NEMA ICS 2, Industrial Control and Systems: Controllers, Contactors and Overload Relays, Rated Not More Than 2000 Volts AC or 750 Volts DC.
D. UL 508, Industrial Control Equipment.

1.5 SUBMITTALS
A. Submit under provisions of the General Requirements and Section 16010.
B. Product Data: Provide catalog sheets showing voltage, controller size, ratings and size of switching and overcurrent protective devices, short circuit ratings, dimensions, and enclosure details.
C. Test Reports: Indicate field test and inspection procedures and test results.
D. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product.
E. Project Record Documents: Record actual locations of controllers in project record documents.
F. Maintenance Data: Include spare parts listing; source and current prices of replacement parts and supplies; and recommended maintenance procedures and intervals.

1.6 QUALIFICATIONS
A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum ten years documented experience.

1.7 REGULATORY REQUIREMENTS
A. Conform to requirements of local electrical codes, unless otherwise specified.
B. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for purpose specified and indicated.

1.8 COORDINATION
A. Coordinate under provisions of the General Requirements and Section 16010.
B. Field Measurements: Verify that field measurements are as shown on Drawings.
C. Field Locations: Verify locations of controllers prior to rough in.

1.9 DELIVERY, STORAGE, PROTECTION, AND HANDLING

A. Deliver, store, protect, and handle products in accordance with recommended practices listed in manufacturer's Installation and Maintenance Manuals.
B. Deliver each combination starter in individual shipping cartons for ease of handling. Each starter shall be wrapped for protection.
C. Inspect and report concealed damage to carrier within specified time.
D. Store in a clean, dry space. Storage temperature shall be minus 30 to plus 65 degrees C. Maintain factory protection or cover to keep out dirt, water, construction debris, and traffic. (Heat enclosures to prevent condensation.)
E. Handle in accordance with NAED and manufacturer's written instruction to avoid damaging combination starters, installed device and finish.

1.10 OPERATION AND MAINTENANCE DATA

A. Manufacturer shall provide copies of installation, operation and maintenance procedures to Owner.
B. Submit operation and maintenance data based on factory and field testing, operation and maintenance of specified product.

1.11 QUALITY ASSURANCE (QUALIFICATIONS)

A. Manufacturer shall be specialized in the manufacture and assembly of combination starters for 10 years.
B. Combination starters shall be listed and/or classified by Underwriters Laboratories in accordance with standards listed in Article 1.03 of this specification.
C. Manufacturer's Certificate of ISO 9000 Compliance.
D. Installer's Certificate of ISO 9000 Compliance.

PART 2 – PRODUCTS

2.1 CONTROLLERS

A. Phase sequence and balance.
   1. Phase sequence: A-B-C, left to right, front to rear, top to bottom.
B. Each NEMA type controller and combination controller, shall be of the same manufacturer.
C. General operating voltage characteristics unless otherwise specified:
   1. Motors ½-horsepower and larger 460-volts, operating on 480-volt, 3-phase, 60 Hertz system.
   2. Motors 1/3-horsepower and smaller 115-volts, operating on 120-volt, 1-phase, 60 Hertz system.
D. Minimum 3 phase starter size: NEMA 1.
E. Manufacturers:
   1. ITE/Siemens
   2. GE
   3. No Substitutions.

2.2 MANUAL CONTROLLERS

A. Fractional Horsepower Manual Controller for motors: NEMA ICS 2, AC general purpose Class A manually operated, full voltage controller for fractional horsepower induction motors, with thermal overload unit, red pilot light, and toggle operator suitable for mounting in standard outlet box.
B. Manual Motor Controller: NEMA ICS 2, AC general purpose Class A manually operated, full voltage controller with auxiliary contacts, red pilot light, START-STOP push button switches, overload elements, and control power transformer.
C. Enclosure: NEMA ICS 6; Type 1, 12, or 3R as suitable for the location.

2.3 AUTOMATIC CONTROLLERS

A. Magnetic Motor Controllers: NEMA ICS 2, AC general purpose Class A automatically operated, full voltage controller with auxiliary contacts, green pilot light, ON-OFF-AUTO selector switch, overload elements, fusible lockable disconnect and control power transformer.
B. Reduced Voltage Controllers: NEMA ICS 2, AC general purpose Class A automatically operated, closed transition reduced voltage autotransformer type controller with 50%, 65%, and 80% tap settings, auxiliary contacts, green pilot light, ON-OFF-AUTO selector switch, overload elements, fusible lockable disconnect and control power transformer.
C. Reversing Controllers: NEMA ICS 2, AC general purpose Class A automatically operated, full voltage controller with auxiliary contacts, green pilot light, ON-OFF-AUTO selector switch, FORWARD-OFF-REVERSE selector switch, overload elements, fusible lockable disconnect, and control power transformer. Include electrical interlock and integral time delay transition between FORWARD and REVERSE rotation.
D. Two Speed Controllers: NEMA ICS 2, AC general purpose Class A automatically operated, full voltage dual single winding controller with auxiliary contacts, green pilot light, ON-OFF-AUTO selector switch, FAST-SLOW selector switch, overload elements, fusible lockable disconnect and control power transformer. Include integral time delay transition between FAST and SLOW speeds. Verify exact starter requirement with mechanical contractor.
E. Enclosure: NEMA ICS 6, Type 1 or 12 or 3R as suitable for the location.
F. Size: The starter shall be large enough to serve the motor being served.

2.4 PRODUCT FEATURES

A. Auxiliary Contacts: NEMA ICS 2, 2 normally open, 2 normally closed field convertible contacts in addition to seal in contact.
B. Cover Mounted Pilot Devices: NEMA ICS 2, heavy duty type.
C. Pilot Device Contacts: NEMA ICS 2, Form Z, rated A150.
D. Indicating Lights: LED type.
E. Selector Switches: Rotary type, on-off-auto.
F. Overload Relays: NEMA ICS; melting alloy, one per phase, wired on the line side of the holding coil.
G. Cover Mounted Overload Relay Reset: Recessed pushbutton type.
H. Relays: NEMA ICS 2.
I. Control Power Transformers: 120-volt secondary with capacity for starter coils, relays, pilot lights, etc. Provide fused primary and secondary, and bond unfused leg of secondary to enclosure.
J. Remote start-stop stations: Include green ON pilot light.

2.5 DISCONNECTS

A. Combination Controllers: Combine motor controllers with non-fusible switch or fusible switch disconnect within common enclosure.
B. Description: Refer to section 16441.

2.6 FUSES

A. Fuse: Class RK-1, dual element, time delay.
B. Description: Refer to section 16481.

2.7 WARNING SIGNS

A. Steel and enamel, painted as follows: WARNING! THIS MOTOR HAS AN AUTOMATIC CONTROL AND MAY START AT ANY TIME

PART 3 – EXECUTION

3.1 EXAMINATION

A. Verify the actual manufacture, size, and location of each motor provided to determine final connection, control, and overcurrent protection selection.

3.2 INSTALLATION

A. Perform Work in accordance with NECA Standard of Installation.
B. Install enclosed controllers where indicated, in accordance with manufacturer's instructions.
C. Install enclosed controllers plumb. Provide supports in accordance with Section 16190.
D. Select and install fuses in motor controller fusible switches to match installed motor characteristics. Verify time-current curves for proper selection.
E. Select and install overload heater elements in motor controllers to match installed motor characteristics.
F. Provide engraved plastic nameplates under the provisions of Section 16195.
G. Provide neatly typed label inside each motor controller door identifying motor served, nameplate horsepower, full load amperes, code letter, service factor, and voltage/phase rating.
H. Install warning signs at automatically controlled motors.

3.3 FIELD QUALITY CONTROL

A. Inspect and test each enclosed controller to NEMA ICS 2.
B. Clean starter enclosure to remove construction debris, dirt, shipping material.
C. Repaint scratched or marred exterior surfaces to match original finish.

END OF SECTION

SECTION 16496

AUTOMATIC TRANSFER SWITCHES (PRE-PURCHASE)

PART 1 – GENERAL

1.1 PRE-PURCHASED EQUIPMENT

A. Kirby School District 140 has elected to pre-bid and purchase the electrical equipment called for in this section of the specifications.
B. Equipment will be shipped to Fernway Elementary School at 16600 S. 88th Ave., Orland Park, IL 60463 and will be unloaded by the installing Electrical Contractor.
C. The equipment manufacturer's representative shall be on site and present at the time of unloading at project site. The Owner's representative, Electrical Contractor, and manufacturer's representative shall inspect the equipment for damage and/or missing components and identify such in writing.
    1. If there are damaged or missing components, the manufacturer's representative shall provide a written list to the Owner.
    2. The Electrical Contractor shall inspect the equipment for damage and/or missing components and identify such in writing. If the contractor agrees the equipment is in proper condition, the manufacturer's representative shall obtain a written acceptance of the equipment from the contractor.
D. The equipment manufacturer's bid/proposal includes start-up services. The equipment manufacturer's bid/proposal includes operating manuals and warranty for parts and labor on equipment only. All other warranty services are by the installing contractor.
    1. Owner's schooling shall be provided under this section.
E. All bidding manufacturers will submit complete product data and shop drawings as outlined in sub-section 1.6 below with their bid/proposal, failure to complete submittals with bid/proposal will be grounds for disqualification.

1.2 RELATED DOCUMENTS

A. The General Provisions of the Contract, including Conditions of the Contract and Division 01 of the Specifications, apply to the work in this Section.
B. This Section is hereby made a part of all other sections of Division 16 as fully as if repeated in each therein.

1.3 SECTION INCLUDES

A. Automatic transfer switch.
B. Accessories.

1.4 RELATED SECTIONS

A. Section 16190 - Supporting Devices.
B. Section 16195 - Electrical Identification.
C. Section 16620 – Natural Gas Generator.

1.5 ASSIGNMENT

A. Equipment will be assigned to the successful mechanical contractor as directed by Owner/Architect/Engineer.

1.6 WORK INCLUDED

A. Delivery of equipment to the job site with a manufacturer's representative present.
B. Parts and labor warranty on Chiller Package from date of delivery.
C. Start-up and Owner's Training on equipment being provided.

1.7 REFERENCES

A. NFPA 70 - National Electrical Code.
B. NEMA ICS 1 - General Standards for Industrial Control and Systems.
C. NEMA ICS 2 - Standards for Industrial Control Devices, Controllers, and Assemblies.
D. NEMA ICS 6 - Enclosures for Industrial Controls and Systems.

1.8 OPERATION AND MAINTENANCE

A. Submit two (2) hard copies and one (1) PDF of manufacturer installation instructions and operation and maintenance data to successful contractor for inclusion in project manual.
B. Include manufacturer's descriptive literature, operating instructions, cleaning procedures, replacement parts list and maintenance and repair data to successful contractor for inclusion in project manual.

1.9 QUALITY ASSURANCE

A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum ten years documented experience.

1.10 HANDLING

A. Comply with manufacturer's installation instruction for rigging, unloading, and transporting units.
B. Protect units from physical damage. Leave factory shipping covers in place until installation.

1.11 WARRANTY

A. Provide two (2) year manufacturer's non-prorated warranty on all parts and two (2) year on labor. See General Requirements for additional requirements and start date.
B. Compressor warranty parts only Years 3rd through 5th.
C. Warranty shall include all control components factory mounted on the unit.

1.12 SUBMITTALS

A. Submit under provisions of Division 01 and Section 16010.
B. Shop Drawings: Indicate voltage, switch size, ratings and size of switching and overcurrent protective devices, operating logic, internal console wiring diagrams, short circuit ratings, dimensions, and enclosure details.
C. Test Reports: Indicate satisfactory completion of tests and inspections required by the authorities having jurisdiction.
D. Manufacturer’s Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of Product.
E. Project Record Documents: Record actual locations of transfer switches in project record documents.
F. Maintenance Data: Include instructions for operating equipment. Include instructions for operating equipment under emergency conditions. Include routine preventative maintenance and lubrication schedule. List special tools, maintenance materials, and replacement parts.
G. Service Proposal: Regular testing services, regular maintenance services

1.13 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum ten years documented experience, and with service facilities within 100 miles of Project.
B. Supplier: Authorized distributor of specified manufacturer with minimum three years documented experience and with a stock of replacement parts for each Product.
C. Servicing: Authorized factory trained full time staffed service department with minimum ten years documented experience specializing in servicing the Products specified, and with service facilities within 100 miles of Project.

1.14 REGULATORY REQUIREMENTS

A. Conform to requirements of NFPA 70, unless otherwise specified.
B. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for the purpose specified and indicated.

1.15 COORDINATION

A. Coordinate under provisions of Division 01 and Section 16010.
B. Field Measurements: Verify that field measurements are as shown on Drawings.
C. Field Locations: Verify locations of transfer switches prior to rough in.
D. Transfer switch to be compatible with Generac emergency generator specified.

1.16 DELIVERY, STORAGE, PROTECTION, AND HANDLING

A. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.
B. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to internal components, enclosure, and finish.

1.17 EXTRA MATERIALS

A. Furnish special tool required for maintenance.

PART 2 – PRODUCTS

2.1 AUTOMATIC TRANSFER SWITCH

A. Manufacturers:
   1. ASCO.
   2. No Substitutions.
B. Description: The transfer switch for “HP” panels serving HVAC equipment shall be delayed transition type and shall incorporate a timed, center-off or neutral position for motor and inductive load decay. Transfer time shall be adjustable from 1 – 5 minutes to either source. A mechanical interlock shall be provided to ensure that both sets of contacts cannot be closed at the same time.
C. Description: NEMA ICS 2, double throw automatic transfer switches for panel EM120 with single operating mechanism.
D. Configuration: Electrically operated, mechanically held with required relays, controls, and contacts.

2.2 RATINGS

A. Voltage: As indicated: 277V/480V.
B. Switched Poles: 4-pole switched neutral with overlapping contacts for 3-phase, 4-wire systems.
C. Amperage: As indicated, 24-hour continuous rating.
D. Load Inrush Rating: Combination tungsten, ballast, resistance, and inductive loads.
E. Withstand Rating: As shown on the drawings or as required for the application.
F. Thermal capacity: 20 times continuous ampere rating for 60 cycles.

2.3 COMPONENTS

A. Phase Sequence: A-B-C, left to right, front to back, top to bottom.
B. Contacts: The main contacts shall be silver surfaced and protected by a separate renewable arcing contact. The normal and emergency contacts shall be inherently mechanically locked by the operating linkage when in the open or closed position. Failure of any coil or disarrangement of any part shall not permit a neutral position.
C. Operating Mechanism: The mechanical driving system and mechanical interlocks shall be electrically dead. Molded plastics parts shall not be used as part of the operating linkage between the electrical operator and the main operating shaft of the switch.
D. Bearings: The main bearings shall be radial ball bearing type.
E. Relays: Sensing and control relays shall be continuous-duty industrial type with wiping contacts rated 10 amperes minimum.
F. Arc Barriers: Each pole shall be equipped with arc barriers and arc suppression.

2.4 ACCESSORIES

A. Indicating Lights: Mount in cover of enclosure to indicate NORMAL SOURCE AVAILABLE, EMERGENCY SOURCE AVAILABLE, LOAD CONNECTION TO NORMAL SOURCE, LOAD CONNECTION TO EMERGENCY SOURCE
B. Test Switch: Mount in cover of enclosure to simulate failure of normal source.
C. Return to Normal Switch: Mount in cover of enclosure to initiate manual transfer from alternate to normal source.
D. Transfer Switch Auxiliary Contacts:
   1. Normal position: 1 set N.O., 1 set N.C.
   2. Emergency Position: 1 set N.O., 1 set N.C.
   3. Time delay normal position: 1 set.
   4. Time delay emergency position: 1 set.
E. Normal Source Monitor: Monitor each phase of normal source voltage and frequency.
F. Emergency Source Monitor: Monitor each phase of emergency source voltage and frequency.
G. In Phase Monitor: Monitor phase timing of normal and emergency sources, for CP-1 ATS only.
H. Exerciser: Provide a timer with load select feature (transfer with or without load) for automatically exercising generator as programmed by Owner.
I. ATS must have RS485 communication link for connection to BAS system for monitoring. Provide Modbus card as required to coordinate with BAS.

2.5 ENCLOSURE

A. Enclosure: ICS 6, Type 1 within electrical room.
B. Finish: Manufacturers standard gray enamel.
C. All current carrying contacts and parts shall be readily accessible from the front for maintenance and inspection without removal of the switch panel, disconnecting of the operating linkage, or disconnecting of power conductors.

2.6 AUTOMATIC SEQUENCE OF OPERATION WITH GENERATOR

A. Initiate Time Delay to Start Emergency Source Engine Generator: Signal from normal source monitor.
   1. Normal Source Monitor: Initiate when normal source voltage drops below 85 percent from rated nominal value or frequency varies more than 5 percent from rated nominal value.
   2. Time Delay to Start Emergency Source Engine Generator: adjustable from 0.5 to 10 seconds, set at 1 second.
B. Initiate Transfer Load to Emergency Source: Signal from normal source monitor, emergency source monitor, and in-phase monitor.
   1. Normal Source Monitor: Initiate when normal source voltage drops below 70 percent from rated nominal value or frequency varies more than 10 percent from rated nominal value.
   2. Emergency Source Monitor: Initiate when emergency source voltage is at least 90 percent of rated nominal value and frequency is within 5 percent of rated nominal value.
   3. In Phase Monitor: If normal and emergency sources are energized, initiate when sources are synchronized to within 15 electrical degrees.
   4. Time Delay to Transfer Load to Emergency Source: adjustable from 0 to 5 minutes, set at 5 seconds as indicated.
C. Initiate Retransfer Load to Normal Source: Signal from normal source monitor and in-phase monitor.
   1. Emergency Source Monitor: Initiate when normal source voltage is at least 90 percent of rated nominal value and frequency is within 5 percent of rated nominal value.
   2. In Phase Monitor: Initiate when sources are synchronized to within 15 electrical degrees.
   3. Time Delay to Transfer Load to Normal Source: adjustable from 0 to 30 minutes, set at 10 minutes as indicated. Bypass time delay in event of emergency source failure.
   4. Time Delay to Shut Down Emergency Source Engine Generator: adjustable from 0 to 30 minutes, set at 15 minutes.

D. Bypass Engine Exerciser: Bypass exerciser control in event of normal source failure during exercising period.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Verify that surface is suitable for transfer switch installation.

3.2 PREPARATION

A. Provide concrete equipment base for floor mounted equipment installation.

3.3 INSTALLATION

A. Install transfer switches in accordance with manufacturer's instructions.
B. Wire, in parallel, each automatic transfer switch to generator start control circuit in generator control panel.
C. Wire auxiliary contacts from automatic transfer switches to Building Automation System, Fire Alarm Control Panel, and Elevator Control Panel.
D. Provide engraved plastic nameplates under the provisions of Section 16195.

3.4 TESTING, ADJUSTMENT, AND DEMONSTRATION

A. Perform test in accordance with the manufacturer’s instructions, unless otherwise specified.
B. Make adjustments as required.
C. Provide service and maintenance of transfer switch for one year from Date of Substantial Completion.
D. Demonstrate operation of transfer switch in bypass, normal, and emergency modes.

END OF SECTION

SECTION 16510

INTERIOR LUMINAIRES

PART 1 – GENERAL

1.1 RELATED DOCUMENTS
A. The General Provisions of the Contract, including Conditions of the Contract and the General Requirement Specifications, apply to the work in this Section.
B. This Section is hereby made a part of all other sections of Division 16 as fully as if repeated in each therein.

1.2 SECTION INCLUDES
A. LED Interior luminaires, drivers and integral controls.
B. Exit signs.
C. Ballasts.
D. Lamps.
E. Luminaire accessories.

1.3 RELATED SECTIONS
A. Section 16190 - Supporting Devices.

1.4 REFERENCES
A. ANSI C78.379 - Electric Lamps - Incandescent and High Intensity Discharge Reflector Lamps - Classification of Beam Patterns.
B. ANSI C82.1 - Ballasts for Fluorescent Lamps - Specifications.
C. ANSI C82.4 - Ballasts for High Intensity Discharge and Low-Pressure Sodium Lamps (Multiple Supply Type).
D. NEMA WD 6 - Wiring Devices Dimensional Requirements.
E. NFPA 70 - National Electrical Code.
F. NFPA 101 - Life Safety Code.
G. IESNA LM-80-08 IESNA - Approved Method for Measuring Lumen Maintenance of LED Light Source.
H. IESNA TM-21-2011 - Projecting Long Term Lumen Maintenance of LED Light Sources.
I. UL 1310 and 8750 - Light Emitting Diode (LED) Equipment for use in Lighting Products.
J. IEC 61347-2-13 - Particular requirements for electronic control gear for LED modules.
K. IEC-62384 - DC or AC supplied electronic control gear for LED modules - performance requirements.
L. IEC 62386-101/102/207 - Digital addressable lighting interface (DALI).

1.5 SUBMITTALS
A. Submit under provisions of the General Requirement Specification Sections and Section 16010.
B. Product Data: Provide for each luminaire, ballast, and lamp. Include dimensions, ratings, and performance data. Data shall be submitted in order of Luminaire Number as identified on drawings.
C. Shop Drawings: Indicate dimensions and components for each luminaire that is not a standard product of the manufacturer.
D. Manufacturer’s Instructions: Indicate application conditions and limitations of use stipulated by Product testing agency specified under Regulatory Requirements. Include instructions for storage, handling, protection, examination, preparation, and installation of Product.
E. Project Record Documents: Record actual locations of luminaires and record actual circuiting arrangements in project record documents.
F. Maintenance Data: Submit manufacturer's operation and maintenance instructions for each product. Include spare parts listing; source and current prices of replacement parts and supplies; and recommended maintenance procedures and intervals.

1.6 QUALIFICATIONS
A. Manufacturer: Company specializing in manufacturing the Products specified in this section with minimum three years documented experience.

1.7 REGULATORY REQUIREMENTS

A. Conform to requirements of local electrical code, unless otherwise specified.
B. Conform to requirements of local electrical code.
C. Furnish products listed and classified by Underwriters Laboratories, Inc. as suitable for the purpose specified and indicated.

1.8 COORDINATION

A. Coordinate under provisions of the General Requirements and Section 16010.
B. Field Measurements: Verify that field measurements are as shown on Drawings.
C. Field Locations: Verify locations of luminaires prior to rough in.

1.9 DELIVERY, STORAGE, PROTECTION, AND HANDLING

A. Protect from moisture by using appropriate coverings. Store in dry interior locations.
B. Do not install until building is closed in and suitable temperature conditions are controlled.
C. Maintain suitable temperature and humidity conditions during and after installation of luminaires.

PART 2 – PRODUCTS

2.1 LUMINAIRES

A. Furnish Products as scheduled.
B. Luminaires for general illumination, emergency lighting, and exit lighting, shall be complete with all required accessories and attachments. Luminaires of the same type shall be of the same manufacturer.
C. Luminaires shall bear Underwriters Laboratories, Inc. label and shall be wired and installed in full compliance with applicable codes.
D. Luminaires shall be recessed, surface, or pendant type, as specified in fixture schedule, and shall include housings, lamp holders, lenses, reflectors, ballasts, lamps, mounting hardware, and other required accessories.
E. Recessed mounted luminaires shall be in compliance with local codes for plenum installation.
F. Enameled finishes shall be electrostatically applied and baked. Finish of fixtures shall be uniform in quality and appearance, durable, and free from defects.
G. Labels and inscriptions in luminaires shall be located in unobtrusive places so that they are not visible to occupants in the completed installation.
H. Plaster frames, angles, and channels for recessed luminaires shall be furnished under this section where required. Plaster frames shall be specifically constructed for the application by the manufacturer of the related luminaire.
I. Recessed incandescent luminaires shall have a thermal protective device within the luminaire housing.
J. Luminaire shall carry the lighting facts label, verified based on LM-85 test reports.

2.2 EXIT SIGNS

A. Furnish Products as scheduled and in compliance with applicable codes.
B. Description: Exit sign fixture.
C. Housing: Sheet steel.
D. Face: Translucent glass face with red letters on white background.
E. Letters: 6" high, with 3/4" stroke, minimum.
F. Directional Arrows: As indicated, with letters 4 1/2" high, 3/4" stroke, minimum.
G. Lamps: Light emitting diodes.
H. Electrical Connections: Conduit connection.
I. Indicators: Lamps to indicate AC-ON and RECHARGING.

2.3 LED LUMINAIRES

A. Each luminaire shall consist of an assembly that utilizes LED's as the light source. In addition, a complete luminaire shall consist of a housing, LED array, and electronic driver (power supply) and integral controls as per this specification.
B. Each luminaire shall be designed to operate at an average operating temperature of 25º C.
C. The operating temperature range shall be 0ºto + 25º
D. Each luminaire shall meet all parameters of this specification throughout the minimum operation life of 50,000 hours when operated at the average operating temperature.
E. Nominal luminaire dimensions: as scheduled.
F. Luminaire Construction:
    1. Luminaire housing to have no visible welding, screws, springs, hooks, rivets, bare LED's or plastic supports.
    2. The luminaire shall be a single, self-contained device, not requiring on-site assembly for installation. The power supply and circuit board for the luminaire shall be integral to the unit.
    3. Luminaires shall be fabricated from post painted cold rolled steel and shall be a rigid structure with integral T-bar clips. Fixture may be mounted and wired in continuous rows.
    4. Finish: Polyester powder coat painted with 92% high-reflective paint after fabrication.
    5. Reflector: rugged one-piece cold rolled steel with linear facets to distribute soft light at multiple angles, without flashing thus reducing high luminance contrast.
    6. End caps shall be sloped at 70 degrees to create depth.
    7. Luminaire to have smooth transition between T-bar and reflector arch. No doorframe or exposed hardware.
    8. Lens shall be impact modified, single clear diffuser with advanced optical film and shall provide LED concealment and even illumination across the diffuser.
    9. Polymeric materials (if used) of enclosures containing either the power supply or electronic components of the luminaire shall be made of UL94VO flame retardant materials. Luminaire lenses are excluded from this requirement.
    10. Integral Grid Clips required on recessed mounted luminaires along with integral tie wire mounting points.
    11. Luminaire to have air removal capability as specified.
    12. The assembly and manufacturing process for the SSL luminaire shall be designed to assure all internal components are adequately supported to withstand mechanical shock and vibration.
G. Led Sources
    1. LED's shall be manufactured by, Nichia, Samsung, LG or Osram.
    2. Lumen Output - minimum initial output of the luminaire shall be as follows for the lumens exiting the luminaire in the 0-90-degree zone - as measured by IESNA Standard LM85 in an accredited lab. Exact tested lumen output shall be clearly noted on the shop drawings.
        a. Type 2x2-2425 (24 watts max.) or 3617 (36 watts max.) initial lumens @ 3500k per specification.
        b. Type 2x4 - 4026 (40 watts max.) or 4740 initial lumens (47 watts max.).
    3. Lumen output shall not decrease by more than 20% over the minimum operational life of 50,000 hours.
    4. Individual LED's shall be connected such that a catastrophic loss or the failure of one LED will not result in the loss of the entire luminaire.
    5. LED boards shall be suitable for field maintenance or service from below the ceiling with plug-in connectors. LED boards shall be upgradable.

6. Light color/quantity:
    a. Correlated color temperature (CCT) range as per specification, between 3500K and 4100 K shall be correlated to chromaticity as defined by the absolute (X, Y) coordinates on the 2-D CIE chromaticity chart.
    b. Color shift over 6,000 hours shall be <0.007 change in u' v' as demonstrated in IES LM8- report.
    c. The color rendition index (CRI) shall be 80 or higher.

H. Power Supply and Driver
1. Driver: Acceptable manufacturer: eldoLED or equal.
2. Ten-year expected life while operating at maximum case temperature and 90% non-condensing relative humidity.
3. Driver shall be UL recognized under the component program and shall be modular for simple field replacement. Drivers that do not meet these requirements will not be accepted.
4. Electrical characteristics: 120 - 277 volt, UL listed, CSA Certified, Sound Rated A+. Driver shall be > 80% efficient at full load across all input voltages. Input wires shall be 18AWG solid copper minimum.
5. Dimming: Driver shall be suitable for full-range dimming. LED dimming shall be equal in range and quality to a commercial grade incandescent dimmer. The luminaire shall be capable of continuous dimming without perceivable flicker over a range of 100 % to 1 % of rated lumen output with a smooth shut off function.
6. Dimming quality to be defined by dimming range, freedom from perceived flicker or visible strobscopic flicker, smooth and continuous change in level (no visible steps in transitions), natural square law response to control input, inaudible in 26db environment, and stable when input voltage conditions fluctuate over what is typically experienced in a commercial environment. Demonstration of this compliance to dimming performance will be necessary for substitutions or prior approval.
    a. Dimming shall be controlled by a 0-10V signal.
    b. Driver shall include ability to provide no light output when the analog control signal drops below 0.5 V, or the DALI/DMX digital signal calls for light to be extinguished and shall consume 0.5 watts or less in this standby. Control dead band between 0.5V and 0.65V shall be included to allow for voltage variation of incoming signal without causing noticeable variation in fixture to fixture output.
    c. Driver shall be capable of configuring a linear or logarithmic dimming curve, allowing fine grained resolution at low light levels.
    d. Driver must be capable of 20-bit dimming resolution for white light LED driver.
    e. Drivers shall track evenly across multiple fixtures at all levels and shall have an input signal to output light level that allows smooth adjustment over the entire dimming range.
7. Flicker: Driver and luminaire electronics shall deliver illumination that is free from objectionable flicker as measured by flicker index (ANSI/IES RP-16-10). At all points within the dimming range from 100-0.1% luminaire shall have:
    a. Less than 1% flicker index at frequencies below 120 HZ.
    b. Less than 12% flicker index at 120 Hz and shall not increase at greater than 0.1% per Hz to a maximum of 80% flicker index at 800Hz.
8. Driver disconnect shall be provided where required to comply with codes.
9. The electronics/power supply enclosure shall be internal to the SSL luminaire and be accessible per UL requirements.
10. The surge protection which resides within the driver shall protect the luminaire from damage and failure for transient voltages and currents as defined in ANSI/IEEE C64.41 2002 for location category A, where failure does not mean a momentary loss of light during the transient event.

I. Electrical
   1. Power Consumption: Maximum power consumption, +/- 5% when operating between 120 - 277V shall be as follows:
      a. Type 2x2 - 24 or 36 W (100 Lumens per watt).
      b. Type 2x4 - 47W (100 Lumens per watt).
   2. Operation Voltage - The luminaire shall operate from a 50 or 60 HZ □3 HZ AC line over a voltage ranging from 120 VAC to 277 VAC. The fluctuations of line voltage shall have no visible effect on the luminous output. The standard operating voltages are 120 VAC and 277 VAC.
   3. Power factor: The luminaire shall have a per factor of 90% or greater at all standard operating voltages and full luminaire output.
   4. THD: Total harmonic distortion (current and voltage) induced into an AC power line by a luminaire shall not exceed 20% at any standard input voltage and meet ANSI C82.11 maximum allowable THD requirements at full output. THD shall at no point in the dimming curve allow imbalance current to exceed full output THD.
   5. Surge Suppression: The luminaire shall include surge protection to withstand high repetition noise and other interference. Withstand up to a 1,000-volt surge without impairment of performance as defined by ANSI C62.41 Category A.
   6. In rush Current: Meet or exceed NEMA 410 driver inrush standard of 430 Amps per 10 Amps load with a maximum of 370 A2s.
   7. RF Interference: The luminaire and associated on-board circuitry must meet Class A emission limits referred in Federal Communications Commission (FCC) Title 47, Subpart B, Section 15 Non-Consumer requirements for EMI/RFI emissions.
   8. Driver must support automatic adaptation, allowing for future luminaire upgrade and enhancements and deliver improved performance.
      a. Adjustment of forward LED voltage, supporting 3V through 60V.
      b. Adjustment of LED current from 200mA to 1.05A at the 100% control input point in increments of 1mA.
      c. Adjustments for operating hours to maintain constant lumens (within 5%) over the 50,000-hour design life of the system and deliver up to 20% energy savings early in the life cycle.
   9. Electrical connections between normal power and driver must be modular utilizing a snap fit connector. All electrical components must be easily accessible after installation and be replaceable without removing the fixture from the ceiling.
   10. All electrical components shall be RoHS compliant.

J. Photometric Requirements:
   1. Luminaire performance shall be tested as described herein.
      a. Luminaire performance shall be judged against the specified minimum illuminance in the specified pattern for a particular application.
      b. Luminaire lighting performance shall be adjusted (depreciated) for the minimum life expectancy (Section 2.2.4).
      c. The performance shall be adjusted (depreciated) by using the LED manufacturer's data from the IESNA Standard TM-21 test report, which ever one results in a higher level of lumen depreciation.
      d. The luminaire may be determined to be compliant photometrical, if:
         1) The initial minimum illuminance level is achieved in 100% of the area of the specified lighting pattern.
         2) The measurements shall be calibrated to standard photopic calibrations.

K. Thermal Management
   1. The thermal management (of the heat generated by the LED's) shall be of sufficient capacity to assure proper operation of the luminaire over the expected useful life (Section 2.2.7 (c)).
   2. The LED manufacturer's maximum junction temperature for the expected life (Section 2.2.7 (c)) shall not be exceeded at the average operating ambient (Section 2.2.2).

3. The LED manufacturer's maximum junction temperature for the catastrophic failure shall not be exceeded at the maximum operating ambient (Section 2.2.3).
4. The luminaire shall have an UL IC rating.
5. The driver manufacturer's maximum case temperature shall not be exceeded at the maximum operating ambient. Thermal management shall be passive by design. The use of fans or other mechanical devices shall not be allowed.

L. Optics
1. The optical assembly shall provide volumetric distribution to eliminate cave effect and provide uniform illumination in the space and increased luminance on vertical surfaces.
2. Optics shall consist of a ribbed metal reflector system and extruded refracting optical lens with high-transmission internal optical film applied to the inside of the refracting lens. No individual LED images shall be visible to the occupant of the space.
3. Refractor or lens shall be 2-piece assembly composed of impact-resistant (20%) DR acrylic with a polymer optical film.
4. 2x2 and 2x4 luminaire shall have center optic and faceted reflector.

M. Integrated (Optional by manufacturer)
1. Each luminaire may be equipped with two (2) digital RJ45 ports and interface with other digital control equipment.
2. May connect to devices compatible with 0 to 10V Analog Control Protocol, Class 2, capable of sinking 0.6ma per driver at a low end of 0.3V. Limit the number of drivers on each 0-10V control output based on voltage drop and control capacity.
3. May connect to digital (DALI Low Voltage Controlled) Dimming drivers.
4. Must meet IEC 62386.
5. May connect to digital multiplex (DMX Low Voltage Controlled) Dimming drivers.
6. Must meet DMX/RDM: USITT DMX512A and ANSI E1.20 (Explore & Address).
7. Lumen Management: The luminaire may be capable of continuously monitoring system performance to allow for constant lumen management/compensation function. Lumen output to be maintained at 80% for life of the luminaire, initial input to be 80% of rated input watts and climb to rated watts by end of rated life of luminaire.
8. Each luminaire may be supplied with a unique network address. This address shall be printed on two identification labels. One label shall be permanently affixed to the luminaire and one label shall be easily removed for network control commissioning purposes. Both labels shall be in a location which is easily accessible by the installing contractor.
9. Control Input:
   a. 4-Wire (0-10V DC Voltage Controlled) Dimming Driver:
      1) Must meet IEC 60929 Annex E for General White Lighting LED drivers.
      2) Must meet ESTA E1.3 for RGBW LED drivers.

N. Luminaire Identification
1. Each luminaire shall have the manufacturer's name, trademark, model number, serial number, date of manufacturer (month-year), and lot number as identification permanently marked inside each unit and the outside of each packaging box.
2. The following operating characteristics shall be permanently marked inside each unit: rated voltage and rated power in Watts and Volt-Ampere.

O. Quality Assurance
1. The luminaires shall be manufactured in accordance with a manufacturer quality assurance (QU) program. The QA program shall include two types of quality assurance: (1) design quality assurance and (2) production quality assurance. The production quality assurance shall include statistically controlled routine tests to ensure minimum performance levels of the modules built to meet this specification. These tests shall include: CCT, CRI, Lumen output and wattage. Tests shall be recorded, analyzed and maintained for future reference.
2. QA process and test results documentation shall be kept on file for a minimum period of seven years.
3. LED luminaire designs not satisfying design qualification testing and the production quality assurance testing performance requirements described below shall not be labeled, advertised, or sold as conforming to this specification.

P. Design Qualification Testing
   1. Design Qualification Testing shall be performed by a National Voluntary Laboratory Accreditation Program (NVLAP) testing facility. Such testing may be performed by the manufacturer or an independent testing lab hired by the manufacturer on new luminaire designs, and when a major design change has been implemented on an existing design. A major design change is defined as a design change (electrical or physical) which changes any of the performance characteristics of the luminaire, results in a different circuit configuration for the power supply or changes the layout of the individual LED's in the module.
   2. A quantity of two units for each design shall be submitted for Design Qualification Testing.
   3. Product submittals shall be accompanied by product specification sheets or other documentation that includes the designed parameters as detailed in this specification. These parameters include (but not limited to):
      a. Maximum power in Watts.
      b. L80 in hours, when extrapolated for the worse case operating temperature (section 2.2.3). TM21 report shall be submitted to demonstrate this.
      c. Product submittals shall be accompanied by performance data that is derived in accordance with appropriate IESNA testing standards and tested in a laboratory that is NVLAP accredited for Energy Efficient Lighting Products.
   4. Luminaire shall be tested per IESNA LM85.

Q. Warranty
   1. The manufacturer shall provide a warranty against loss of performance and defects in materials and workmanship for the Luminaires for a period of 5 years after acceptance of the Luminaires. Warranty shall cover all components comprising the luminaire. All warranty documentation shall be provided to customer prior to the first shipment.
   2. Provide manufacturer's warranty covering 5 years on drivers from date of purchase. Refer to manufacturer's terms and conditions on the website for detailed information.

PART 3 – EXECUTION

3.1 INSTALLATION

A. Install suspended luminaires and exit signs directly from building structure using rigid stem pendants supported from swivel hangers. Provide pendant length required to suspend luminaire at indicated height.
B. Support luminaires larger than 2'x 4' size independent of ceiling framing.
C. Locate recessed ceiling luminaires as indicated on reflected ceiling plan.
D. Install surface mounted luminaires and exit signs plumb and adjust to align with building lines and with each other. Secure to prevent movement.
E. Grid Ceilings: Provide auxiliary members spanning ceiling grid members to support surface mounted luminaires. Fasten surface mounted luminaires to ceiling grid members using bolts, screws, rivets, or suitable clips.
F. Install recessed luminaires to permit removal from below.
G. Install recessed luminaires using accessories and fire stopping materials to meet regulatory requirements for fire rating.
H. Install clips to secure recessed grid supported luminaires in compliance with applicable codes.
I. Install wall mounted luminaires and exit signs at height as shown.
J. Install accessories furnished with each luminaire.
K. Connect luminaires and exit signs to emergency power as indicated branch circuit under Section 16130 using flexible conduit, 3/8" minimum.
L. Make wiring connections to branch circuit using building wire with insulation suitable for temperature conditions within luminaire.
   1. Recessed LED: AWG No. 14 RHH or THWN.

M. Bond products and metal accessories to branch circuit separate green equipment grounding conductor.
N. Install specified lamps in each luminaire and exit sign in accordance with manufactures instructions for handling and burning position.

3.2 INTERFACE WITH OTHER PRODUCTS

A. Coordinate installation of recessed luminaire frames and trims with ceiling construction.
B. Coordinate the installation of suspended luminaires with building components, verify exact locations and mounting heights.

3.3 FIELD QUALITY CONTROL

A. The use of permanent luminaires for temporary lighting shall only be as permitted by the Architect/Engineer.
B. Operate each luminaire after installation and connection. Inspect for proper connection and operation.

3.4 ADJUSTING

A. Adjust installed work under provisions of the General Requirement Specification Sections.
B. Aim and adjust luminaires as indicated and as directed.
C. Position exit sign directional arrows as indicated.

3.5 CLEANING

A. Clean installed work under provisions of the General Requirement Specification Sections.
B. Clean electrical parts to remove conductive and deleterious materials.
C. Remove dirt and debris from enclosures.
D. Clean photometric control surfaces to remove all dust and smudges with cleaning solution as recommended by manufacturer.
E. Clean finishes and touch up damage.

3.6 DEMONSTRATION AND INSTRUCTIONS

A. Demonstrate installed work under provisions of the General Requirement Specification Sections.
B. Demonstrate luminaire operation for minimum of two hours.

3.7 PROTECTION OF FINISHED WORK

A. Protect installed work under provisions of the General Requirement Specification Sections.
B. Re-lamp luminaires used for temporary lighting and luminaires that have failed lamps at the time of project turn-over.

END OF SECTION

SECTION 16515

INTERIOR LUMINAIRES LED DIMMING DRIVERS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

A. The General Provisions of the Contract, including Conditions of the Contract and the General Requirement Specifications, apply to the work in this Section.
B. This Section is hereby made a part of all other sections of Division 16 as fully as if repeated in each therein.

1.2 RELATED SECTIONS

A. Edit the following subparagraphs to coordinate with other sections in the Project Manual.
B. Section 16140 - Wiring Devices
C. Section 16510 - Interior Luminaries

1.3 REFERENCES

A. Underwriters Laboratories, Inc. (UL)
   1. 1310 and 8750 - Light Emitting Diode (LED) equipment for use in lighting products.
B. American National Standards Institute (ANSI)
   1. ANSI C82.11 - Performance requirement for high frequency ballasts.
   2. ANSI/IES RP-16-10 - Nomenclature and definitions for illuminating engineering.
   3. ANSIE1.20 - Remote Device Management Over DMX512 Networks.
   4. ANSI C62.41 - Recommended practice in low power circuits.
C. International Electro Technical Commission (IEC).
   1. IEC 61347-1 - General and safety requirements for lamp control gear.
   2. IEC 61347-2-13 - Particular requirements for electronic control gear for LED modules.
   3. IEC 62384 - DC or AC supplied electronic control gear for LED modules - performance requirements.
   4. IEC 61000-3-2 - Harmonic current emissions.
   5. IEC 61547 - EMC immunity requirements.
   6. IEC 62386 -101/102/207 - Digital addressable lighting interface (DALI).
D. European Mark of electro technical products (ENEC)
   1. EN55015 - Radio disturbances <30 Mhz.
   2. EN55022 - Performance requirement for EMC, information technology and Telecommunications equipment.
   3. EN60929/IEC60929 - Performance requirement for AC supplied electronic equipment.
E. Federal Communications Commission (FCC) rules - Part 15 Class B : Radio Frequency Devices.
   1. Commercial rated.
F. Entertainment Services and Technology Association.
   1. ESTA E1.3 - Entertainment Technology - Lighting Control System - 0 to 10V Analog Control Protocol.

1.4 SUBMITTALS

A. See Section 16010
B. Shop Drawings: Clearly indicate the name of the job, Architects/Engineer and list fixture type (s) for each specific driver. Contractor shall endeavor to submit all drivers as one package along with the luminaire package.
C. Product Data: Provide dimensions, ratings and specific catalog number and identification of items and accessories and performance data.
D. Wiring Diagrams - as needed for special operation or interaction with other system (s).

1.5 DESCRIPTION

A. LED dimming driver.
   1. 4-Wire (0-10V DC Voltage Controlled) Dimming Drivers.
   2. Digital (DALI Low Voltage Controlled) Dimming Drivers.
   3. Digital Multiplex (DMX Low Voltage Controlled) Dimming Drivers.

1.6 QUALITY ASSURANCE

A. Manufacturer: Minimum 5 years' experience in manufacture of dimmable electronic lighting drivers.
B. Recognized by UL for use in the US and Canada. Provide evidence of compliance upon request.

1.7 PROJECT CONDITIONS

A. Do not install equipment until following conditions can be maintained in spaces to receive equipment:
   1. Ambient temperature: -20 degrees to 50 degrees C (-4 degrees to 122 degrees F).
   2. Relative humidity: Maximum 90 percent, non-condensing.
   3. Protected from dust and excess moisture during installation.

1.8 WARRANTY

A. Provide manufacturer's warranty covering 5 years on drivers from date of purchase. Luminaire manufacturer to operate driver at or below the required driver warranty temperature. Luminaire manufacturers failing to operate the driver, at the project required ambient temperature, within the driver manufacturer warranty parameters will be responsible for all driver warranty related costs over the warranty period.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

A. Acceptable Manufacturer: eldoLED or equal.

2.2 GENERAL

A. LED dimming shall be equal in range and quality to a commercial grade incandescent dimmer. Quality of dimming to be defined by dimming range, freedom from perceived flicker or visible stroboscopic flicker, smooth and continuous change in level (no visible steps in transitions), natural square law response to control input, and stable when input voltage conditions fluctuate over what is typically experience in a commercial environment. Demonstration of this compliance to dimming performance will be necessary for substitutions or prior approval.
B. Ten-year expected life while operating at maximum case temperature and 90 percent non-condensing relative humidity.
C. Driver must limit inrush current:
   1. Base specification: Meet or exceed NEMA 410 driver inrush standard of 430 Amps per 10 Amps load with a maximum of 370 Amps2 - seconds.
   2. Preferred Specification: Meet or exceed 30mA2s at 277VAC for up to 50 watts of load and 75A at 240us at 277VAC for 100 watts of load.
D. Withstand up to 1,000-volt surge without impairment of performance as defined by ANSI C62.41 Category A.
E. No visible change in light output with a variation of plus/minus 10 percent line voltage input.
F. Total Harmonic Distortion less than 20% percent and meet ANSI C82.11 maximum allowable THD requirements at full output. THD shall at no point in the dimming curve allow imbalance current to exceed full output THD.
G. Diver must support automatic adaptation, allowing for future luminaire upgrades and enhancements and deliver improved performance:
   1. Adjustment of forward LED voltage, supporting 3V through 55V.
   2. Adjustment of LED current from 200mA to 1.05A at the 100 percent control input point in increments of 1mA.
   3. Adjustment for operating hours to maintain constant lumens (within 5 percent) over the 50,000-hour design life of the system and deliver up to 20 percent energy savings early in the life cycle.

H. Driver must be able to operate for a (+/- 10%) supply voltage of 120V through 277VAC at 60Hz.
I. Driver should be UL Recognized under the component program and shall be modular for simple field replacement. Drivers that are not UL Recognized or not suited for field replacement will not be considered.
J. Driver shall include ability to provide no light output when the analog control signal drops below 0.5 V, or the DALI/DMX digital signal calls for light to be extinguished and shall consume 0.5 watts or less in this standby. Control dead band between 0.5V and 0.65V shall be included to allow for voltage variation of incoming signal without causing noticeable variation in fixture to fixture output.

2.3 LIGHT QUALITY

A. Over the entire range of available drive currents, driver shall provide step-free, continuous dimming to black from 100 percent to 0.1 percent and 0% relative light output, or 100 - 1% light output and step to 0% where indicated. Driver shall respond similarly when raising from 0% to 100%.
   1. Driver must be capable of 20-bit dimming resolution for white light LED drivers or 15-bit resolution for RGBW LED drivers.
B. Driver must be capable of configuring a linear or logarithmic dimming curve, allowing fine grained resolution at low light levels.
C. Drivers to track evenly across multiple fixtures at all light levels and shall have an input signal to output light level that allows smooth adjustment over the entire dimming range.
D. Driver and luminaire electronics shall deliver illumination that is free from objectionable flicker as measured by flicker index (ANSI/IES RP-16-10). At all points within the dimming range from 100-0.1 percent luminaire shall have:
   1. LED dimming driver shall provide continuous step-free, flicker free dimming similar to incandescent source.
   2. Base specification: Flicker index shall less than 5% at all frequencies below 1000 Hz.
   3. Preferred specification: Flicker index shall be equal to incandescent, less than 1% at all frequencies below 1000 Hz.

2.4 CONTROL INPUT

A. 4-Wire (0-10V DC Voltage Controlled) Dimming Drivers
   1. Must meet IEC 60929 Annex E for General White Lighting LED drivers.
   2. Connect to device compatible with 0 to 10V Analog Control Protocol, Class2, capable of sinking 0.6 ma per driver at a low end of 0.3V. Limit the number of drivers on each 0-10V control output based on voltage drop and control capacity.
   3. Must meet ESTA E1.3 or RGBW LED drivers.
B. Digital (DALI Low Voltage Controlled) Dimming Drivers.
   1. Must meet IEC 62386.
C. Digital Multiplex (DMX Low Voltage Controlled Dimming Drivers.
   1. Must meet DMX/RDM: USITT DMX512A and ANSI E1.20 (Explore & Address).
   2. Capable of signal interpolation and smoothing of color and intensity transitions.

PART 3 – EXECUTION

3.1 INSTALLATION

A. To be installed per manufacturers prescribed methods.
B. Driver may be remote mounted up to 300 ft. (100 m) depending on power level and wire gauge.
C. 0-10 V input shall be protected from line voltage mis-wire and shall be immune and output unresponsive to induce AC voltage on the control leads.

END OF SECTION

SECTION 16620

NATURAL GAS GENERATOR (PRE-PURCHASE)

PART 1 - GENERAL

1.1 PRE-PURCHASED EQUIPMENT

A. Kirby School District 140 has elected to pre-bid and purchase the electrical equipment called for in this section of the specifications.
B. Equipment will be shipped to Fernway Elementary School at 16600 S. 88th Ave., Orland Park, IL 60463 and will be unloaded by the installing Electrical Contractor.
C. The equipment manufacturer's representative shall be on site and present at the time of unloading at project site. The Owner's representative, Electrical Contractor, and manufacturer's representative shall inspect the equipment for damage and/or missing components and identify such in writing.
    1. If there are damaged or missing components, the manufacturer's representative shall provide a written list to the Owner.
    2. An Electrical Contractor shall inspect the equipment for damage and/or missing components and identify such in writing. If the contractor agrees the equipment is in proper condition, the manufacturer's representative shall obtain a written acceptance of the equipment from the contractor.
D. The equipment manufacturer's bid/proposal includes start-up services. The equipment manufacturer's bid/proposal includes operating manuals and warranty for parts and labor on equipment only. All other warranty services are by the installing contractor.
    1. Owner's schooling shall be provided under this section.
E. All bidding manufacturers must submit complete product data and shop drawings as outlined in sub-section 1.6 below with their bid/proposal, failure to complete submittals with bid/proposal will be grounds for disqualification.

1.2 SECTION INCLUDES

A. Delivery of equipment to the job site with a manufacturer's representative present.
B. Field start-up services and Owner training at the job site.
C. Parts and labor warranty.
D. Chiller package.
E. Controls and control connections
F. Starters.
G. Electrical power connections.
H. Remote air-cooled condensers.

1.3 ASSIGNMENT

A. Equipment will be assigned to the successful mechanical contractor as directed by Owner/Architect/Engineer.

1.4 WORK INCLUDED

A. Delivery of equipment to the job site with a manufacturer's representative present.
B. Parts and labor warranty on Emergency Generator from date of delivery.
C. Start-up and Owner's Training on equipment being provided.

1.5 SUBMITTALS

A. Submit two (2) copies of unit performance data including capacity, nominal and operating performance.
B. Submit Mechanical Specifications for unit and accessories describing construction, components, and options.
C. Submit shop drawings indicating overall dimensions as well as installation, operation, and service clearances. Indicate lift points and recommendations and center of gravity. Indicate unit shipping, installation and operating weights including dimensions.
D. Submit data on electrical requirements and connection points. Include recommended wire and fuse sizes or MCA, sequence of operation, safety, and start-up instructions.

1.6 OPERATION AND MAINTENANCE

A. Submit two (2) hard copies and one (1) PDF of manufacturer installation instructions and operation and maintenance data to successful contractor for inclusion in project manual.
B. Include manufacturer's descriptive literature, operating instructions, cleaning procedures, replacement parts list and maintenance and repair data to successful contractor for inclusion in project manual.

1.7 QUALITY ASSURANCE

A. Manufacturer: Company specializing in manufacturing the products specified in this Section with minimum ten years documented experience.

1.8 HANDLING

A. Comply with manufacturer's installation instruction for rigging, unloading, and transporting units.
B. Protect units from physical damage. Leave factory shipping covers in place until installation.

1.9 WARRANTY

A. Provide two (2) year manufacturer's non-prorated warranty on all parts and two (2) year on labor. See General Requirements for additional requirements and start date.
B. Compressor warranty parts only Years 3rd through 5th.
C. Warranty shall include all control components factory mounted on the unit.

1.10 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.11 SUMMARY

A. Section includes installation of packaged engine-generator set for emergency power supply with the following features:
    1. 250 kW Natural Gas Generator with level 2 sound attenuated enclosure. The generator enclosure will be furnished and installed by the Contractor, including all connections, including control and power connections.
        a. Gas engine.
        b. Unit-mounted cooling system.
        c. Unit-mounted control and monitoring.
        d. Performance requirements for sensitive loads.
        e. Fuel system.
        f. Outdoor enclosure.

1.12 DEFINITIONS

A. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.
B. EPS: Emergency power supply.
C. EPSS: Emergency power supply system.
D. Emergency Power Supply: NEC700, essential for life safety loads. Generator to meet NFPA 110 Level 1.

1.13 ACTION SUBMITTALS

A. Product Data: For each type of product.
    1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
    2. Include thermal damage curve for generator.
    3. Include time-current characteristic curves for generator protective device.
    4. Include fuel consumption in cubic feet per hour at 0.8 power factor at 0.5, 0.75- and 1.0-times generator capacity.

5. Include generator efficiency at 0.8 power factor at 0.5, 0.75- and 1.0-times generator capacity.
6. Include air flow requirements for cooling and combustion air in cfm at 0.8 power factor and rated load. Testing shall be performed per ISO3046 standards. Provide drawings showing requirements and limitations for location of air intake and exhausts.
7. Include generator characteristics, including, but not limited to kw rating, efficiency, reactances, and short-circuit current capability.

B. Shop Drawings:
1. Include details of all electrical and gas connections, so the Owner-furnished generator will be correctly installed.
2. Include details of equipment assemblies. Indicate dimensions, weights, center of gravity of full assembly, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Identify fluid drain ports and clearance requirements for proper fluid drain.
4. Design calculations for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
5. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include base weights.
6. Include diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams showing terminal markings for EPS equipment and functional relationship between all electrical components.

1.14 INFORMATIONAL SUBMITTALS

A. Coordinate "Qualification Data" Paragraph below with qualification requirements in Section 014000 "Quality Requirements" and as may be supplemented in "Quality Assurance" Article.
1. Statement of quality from manufacturer detailing acceptance as an ISO9001 manufacturer.

B. Source quality-control reports, including, but not limited to the following:
1. Certified summary of prototype-unit test report.
2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
3. Certified Summary of Performance Tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.
4. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
5. Report of sound generation.
6. Report of exhaust emissions showing compliance with applicable regulations.
7. Certified Torsional Vibration Compatibility: Comply with NFPA 110.

C. Field quality-control reports.

D. Warranty: For special warranty.

1.15 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For packaged engine generators to include in emergency, operation, and maintenance manuals.
1. In addition to items specified in Division 1, include the following:
a. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.
b. Operating instructions laminated and mounted adjacent to generator location.
c. Training plan.

1.16 MAINTENANCE MATERIAL

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
1. Filters: One set each of lubricating oil, fuel, and combustion-air filters.
2. Special Tools: Tools unique to the product for standard maintenance, listed by part number in operations and maintenance manual.

SECTION 16620

NATURAL GAS GENERATOR (PRE-PURCHASE)

1.17 QUALITY ASSURANCE

A. Manufacturer Qualifications: Manufacturer accepted as an ISO9001 manufacturer.
B. Installer Qualifications: Manufacturer's authorized representative who is trained and approved by manufacturer.
C. Third-Party Testing Agency Qualifications: Member company of NETA or an NRTL.
   1. Testing Agency's Field Supervisor: Certified by NETA to supervise on-site testing.

PART 2 - PART 2 – PRODUCTS

2.1 MANUFACTURERS

A. Approved Product: provide Kohler Power Systems; natural gas model 250REZXB generator set, rated 250 KW Standby, at 277/480 Volt 3-phase, 4-wire, 60 hz.
   1. No substitutions.
B. Source Limitations: Obtain packaged generator sets and auxiliary components (except transfer switch) through one source from a single manufacturer. Generator set shall be standard offering from manufacturer. No special ratings will be permitted.
C. Engineering changes resulting from the substitution of another product will be the responsibility of the electrical contractor.

2.2 PERFORMANCE REQUIREMENTS

A. NFPA Compliance:
   1. Comply with NFPA 70.
   2. Comply with NFPA 110 requirements for Level 1emergency power supply system.
B. UL Compliance: Comply with UL 2200/CSA.
C. Engine Exhaust Emissions: Comply with EPA Tier requirements and applicable state and local government requirements.
D. Environmental Conditions: Engine-generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:
   1. Ambient Temperature: -20 to 40 deg. C for spark-ignited.
   2. Relative Humidity: Zero to 95 percent.
   3. Altitude: Sea level to 700 Feet

2.3 ASSEMBLY DESCRIPTION

A. Factory-assembled and -tested, water-cooled engine, with brushless generator and accessories.
B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended location and application.
C. Governor: Adjustable isochronous, with speed sensing.
D. Emissions: Comply with EPA Tier and local requirements for stand by generation.
E. Mounting Frame: Structural steel framework to maintain alignment of mounted components without depending on concrete foundation. Provide lifting attachments sized and spaced to prevent deflection of base during lifting and moving.
   1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.
F. Capacities and Characteristics:
   1. Power Output Ratings: Nominal ratings as indicated at 0.8 power factor excluding power required for the continued and repeated operation of the unit and auxiliaries.
   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 components. Nameplate shall be in accordance with NFPA70.

G. Generator-Set Performance:
   1. Oversizing alternator compared with the rated power output of the engine is permissible to meet specified performance.
      a. Nameplate Data for Oversized Generator: Show ratings required by the Contract Documents rather than ratings that would normally be applied to generator size installed.
   2. Steady-State Voltage Operational Bandwidth: 1 percent of rated output voltage from no load to full load.
   3. 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 5 seconds.
   4. Steady-State Frequency Operational Bandwidth: Plus or minus 0.25 percent of rated frequency from no load to full load.
   5. 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.
   6. Transient Frequency Performance: Less than 5-Hz variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within 5 seconds.
   7. Output Waveform: At no load, harmonic content measured line to neutral shall not exceed 2 percent total with no slot ripple. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
   8. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 300 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to winding insulation or other generator system components.
   9. Block Load Performance: per NFPA110, the unit shall be able to fully recover from a 100% block load.
   10. Excitation System: Performance shall be unaffected by 10% total voltage distortion (THD) caused by nonlinear load.
   11. Provide permanent magnet excitation (PMG) for power source to voltage regulator.
   12. Start Time: Comply with NFPA 110, Type 10, system requirements.

2.4 ENGINE

A. Fuel: Natural gas.
B. Engine Rating: Prime mover shall have adequate horsepower to meet the specified kW at the specified site altitude and temperatures. Products that de-rate below specified kW for temperature or altitude shall not be accepted.
C. Maximum Piston Speed for Four-Cycle Engines: 1800 fpm
D. Lubrication System: The following items are mounted on engine or skid:
   1. Filter and Strainer: Per manufacturer recommendations.
   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. Jacket Coolant Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with NFPA 110 requirements for Level 1 equipment for heater capacity.
F. 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. Cooling System Sizing: Sized to adequately cool the generator set, including aftercooler, without de-rate to an ambient temperature of 104 deg. F for gas. Maximum external restriction shall be no greater than 0.5 inch of water column.

3. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
4. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
5. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
6. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.
    a. Rating: 50-psig maximum working pressure with coolant at 180 deg. F, and non-collapsible under vacuum.
    b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

G. Air-Intake Filter: Engine-mounted air cleaner with replaceable dry-filter element.
H. Starting System: 12-V electric, with negative ground.
    1. Components: Sized so they are not damaged during a full engine-cranking cycle with ambient temperature at maximum specified in "Performance Requirements" Article.
    2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
    3. Cranking Cycle: As required by NFPA 110 for system level specified.
    4. Battery: Lead acid, certified to meet NFPA 110, with capacity within ambient temperature range specified in "Performance Requirements" Article to provide specified cranking cycle at least three times without recharging.
    5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
    6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 10 deg. C regardless of external ambient temperature within range specified in "Performance Requirements" Article. Include accessories required to support and fasten batteries in place. Provide ventilation to exhaust battery gases.
    7. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and continuous rating adequate for batteries provided.
    8. Battery Charger: Current-limiting, automatic-equalizing and float-charging type designed for lead-acid batteries. Unit shall comply with UL 1236 and include the following features:
        a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
        b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg. F to 140 deg. F to prevent overcharging at high temperatures and undercharging at low temperatures.
        c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
        d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
        e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
        f. Enclosure and Mounting: NEMA 250, Type 1, wall-mounted cabinet with adequate vibration isolation if mounted within the generator set.
        g. Battery chargers mounted within the Automatic Transfer Switch are not acceptable.

2.5 GASEOUS FUEL SYSTEM

A. Natural-Gas Piping: Comply with requirements of Division 15 piping specification, and with requirements of NFPA 37 and 54.
   1. Gas piping is the responsibility of the installing contractor.
   2. Gas piping shall be sized to provide adequate fuel to the engine while allowing for no greater than 1-inch water column pressure drop from no load to full load.
   3. Natural gas piping will supply pressure to the generator set inlet per manufacturer's recommendations, nominally 11 to 14 inches of water column.
   4. Natural gas regulator shall be sized to provide 125 percent of full-load generator set capacity.

B. Gas Train: Comply with NFPA 37.

C. Engine Fuel System:
   1. Natural-Gas, Vapor-Withdrawal System:
      a. Carburetor.
      b. Secondary Gas Regulators: One for each fuel type, with atmospheric vents piped to building exterior.
      c. Fuel-Shutoff Solenoid Valves: NRTL-listed, normally closed, safety shutoff valves; one for each fuel source.
      d. Fuel Filters: One for each fuel type.
      e. Manual Fuel Shutoff Valves: One for each fuel type.
      f. Flexible Fuel Connectors: Minimum one for each fuel connection.

2.6 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 manual 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 manual 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. Provide minimum run time control set for 30 minutes with override only by operation of a remote emergency-stop switch.

D. Comply with UL 508A.

E. 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. Panel shall be powered from the engine-generator set battery.
   1. Engine and generator control wiring shall be multi-stranded annealed copper conductors encased by cross-linked polyethylene insulation resistant to heat, abrasion, oil, water, diesel fuel, and antifreeze. Wiring shall be suitable for continuous use at 250 deg. F with insulation not brittle at minus 60 deg. F. Cables shall be enclosed in nylon flexible conduit, which is slotted to allow easy access and moisture to escape.
      a. Engines that are equipped with an electronic engine control module (ECM) shall monitor and control engine functionality and seamlessly integrate with the generator set controller through digital communications. ECM monitored parameters shall be integrated into the genset controllers NFPA 110 alarm and warning requirements.
      b. For engines without ECM functionality or for any additional generator set controller monitoring, sensors are to be conditioned to a 4 to 20 ma signal level to enhance noise immunity and all sensor connections shall be sealed to prevent corrosion.

2. Construction: All circuitry within the control panel shall be individually environmentally sealed to prevent corrosion. Encapsulated circuit boards with surface mounted components and sealed, automotive-style connectors for sensors and circuit board connectors. Enclosed circuit boards and terminal strips that are susceptible to corrosion are not acceptable.
3. Custom ladder logic functionality inside the generator controller shall be supported to provide application support flexibility. The ladder logic function shall have access to all the controller inputs and customer assignable outputs.

F. Indicating Devices: As required by NFPA 110 for Level 1 system. All ECM fault codes shall be displayed at the generator set controller in standard language; fault code numbers are not acceptable. Utilizing a digital display, including the following:
1. AC voltage: True three-phase sensing.
2. AC current.
3. Frequency.
4. EPS supplying load indicator.
5. DC voltage (alternator battery charging).
6. Engine-coolant temperature.
7. Engine lubricating-oil pressure.
8. Running-time meter.
9. Current and Potential Transformers: Instrument accuracy class.

G. Protective Devices and Controls in Local Control Panel: Shutdown devices and common visual alarm indication as required by NFPA 110 for Level 1system, including the following:
1. Start-stop switch.
2. Overcrank shutdown device.
3. Overspeed shutdown device.
4. Coolant high-temperature shutdown device.
5. Coolant low-level shutdown device.
6. Low lube oil pressure shutdown device.
7. Overcrank alarm.
8. Overspeed alarm.
9. Coolant high-temperature alarm.
10. Coolant low-temperature alarm.
11. Coolant low-level alarm.
12. Low lube oil pressure alarm.
13. Lamp test.
14. Contacts for local and remote common alarm.
15. Coolant high-temperature pre-alarm.
16. Generator-voltage; digitally adjustable via controller, password protected.
17. Main fuel low-pressure alarm.
18. Run-Off-Manual selector switch.
19. Control switch not in automatic position alarm.
20. Low cranking voltage alarm.
21. Battery-charger malfunction alarm.
22. Battery low-voltage alarm.
23. Battery high-voltage alarm.
24. Generator overcurrent protective device not closed alarm.

H. 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. Sensors are to be conditioned to a 4 to 20 mA signal level to enhance noise immunity and all sensor connections shall be sealed to prevent corrosions.

I. Connection to Datalink: Provide connections for datalink transmission of indications to remote data terminals via ModBus RS232. Data system connections to terminals are covered in Section 260913 "Electrical Power Monitoring and Control."

J. Remote Alarm Annunciator: Comply with NFPA 99. An LED labeled with proper alarm conditions shall identify each alarm event, and a common audible signal shall sound for each alarm condition. Silencing switch in face of panel shall silence signal without altering visual indication. Connect so that after an alarm is silenced, clearing of initiating condition will reactivate alarm until silencing switch is reset. Cabinet and faceplate are surface- or flush-mounting type to suit mounting conditions indicated.
   1. Overcrank alarm.
   2. Coolant low-temperature alarm.
   3. High engine temperature pre-alarm.
   4. High engine temperature alarm.
   5. Low lube oil pressure alarm.
   6. Overspeed alarm.
   7. Low fuel pressure alarm.
   8. Low coolant level alarm.
   9. Low cranking voltage alarm.
   10. Contacts for local and remote common alarm.
   11. Audible-alarm silencing switch.
   12. Control switch not in automatic position alarm.
   13. Lamp test.
   14. Low cranking voltage alarm.
   15. Generator overcurrent protective device not closed.

K. The control system shall provide pre-wired customer use I/O: 4 relay outputs (user definable functions), 4 contact inputs, 2 analog inputs, communications support via RS232, RS485, or an optional modem. Additional I/O must be an available option. Customer I/O shall be software configurable providing full access to all alarm, event, data logging, and shutdown functionality.

L. 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.

M. Maintenance:
   1. All engine, voltage regulator, control panel, and accessory units shall be accessible through a single electronic service tool. The following maintenance functionality shall be integral to the generator set controls:
      a. Engine running hours.
      b. Service maintenance interval (running hours, calendar days).
      c. Engine crank attempt counter.
      d. Engine successful starts counter.
      e. 20 events are stored in control panel memory.
      f. Control panel shall time and date stamp all alarms and warnings. A snap shot of key parameters shall be saved in the control panel for use in troubleshooting alarms.
      g. A predictive maintenance algorithm will determine the optimal time for maintenance service based on the generator loading and operation.

N. Programmable Cycle Timer: To start and run the generator for a predetermined time. The timer shall use 14 user-programmable sequences that are repeated in a 7-day cycle. Each sequence shall have the following programmable set points:
   1. Day of the week.
   2. Time of the day start.
   3. Duration of cycle.
   4. Option to exercise at reduced speed for quiet test mode.
   5. Ability to program custom I/O alarms as well as modify standard alarm settings for applications (password protected).

2.7 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Overcurrent protective devices for the entire EPSS shall be coordinated to optimize selective tripping when a short circuit occurs. Coordination of protective devices shall consider both utility and EPSS as the voltage source.

1. Overcurrent protective devices for the EPSS shall be accessible only to authorized personnel and each located in a separate box per NEC700 separation of circuits.

B. Generator Circuit Breaker: Molded-case, thermal-magnetic type; 80 percent rated; complying with UL 489.
   1. Tripping Characteristic: Designed specifically for generator protection.
   2. Trip Rating: Matched to generator output rating.
   3. Mounting: Each circuit breaker installed in separate box in accordance with NEC700 separation of circuits.

C. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other generator-set protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector performs the following functions:
   1. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other generator-set malfunction alarms. Contacts shall be available for load shed functions.
   2. Under single or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.
   3. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the generator set.
   4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.

2.8 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1 and UL2200, sized for 248 deg F temperature rise above ambient at rated load.
B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.
C. Electrical Insulation: Class H.
D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required. Provide 12 lead alternator.
E. Winding Coils: Skewed to improve sine wave shape and eliminate ripple effects caused by air gaps.
F. Range: Provide broad range of output voltage by adjusting the excitation level.
G. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, over-speed up to 125 percent of rated speed, and heat during operation at 110 percent of rated capacity.
H. Enclosure: Drip-proof.
I. Instrument Transformers: Mounted within generator enclosure.
J. Voltage Regulator: Solid-state type on a sealed circuit board, separate from exciter, providing performance as specified and as required by NFPA 110. Must be 3-phase sensing.
   1. Voltage Adjustment on Control and Monitoring Panel: Provide plus or minus 5 percent adjustment of output-voltage operating band.
   2. Provide anti-hunt provision to stabilize voltage.
K. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.
L. Excitation: Permanent magnet (PMG) type providing 300 percent current output for up to 10 seconds to a downstream breaker selective coordination and improved motor starting.

2.9 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, Level 1 Energy Converters and with IEEE 115.

PART 3 - PART 3 – EXECUTION

3.1 EXAMINATION

A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine-generator performance.
B. Examine roughing-in for piping systems and electrical connections. Verify actual locations of connections before packaged engine-generator installation.
C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
   1. Notify Construction Manager no fewer than 2 working days in advance of proposed interruption of electrical service.
   2. Do not proceed with interruption of electrical service without Construction Manager's written permission.

3.3 INSTALLATION

A. Comply with packaged engine-generator manufacturers' written installation and alignment instructions and with NFPA 110.
B. Equipment Mounting:
   1. Install packaged engine generators on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Architectural Specifications.
   2. Coordinate size and location of concrete bases for packaged engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
C. Install packaged engine-generator to provide access, without removing connections or accessories, for periodic maintenance.
D. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.4 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping and specialties.
B. Connect fuel, cooling-system, and exhaust-system piping adjacent to packaged engine-generator to allow service and maintenance.
C. Connect engine exhaust pipe to engine with flexible connector.
D. Connect fuel piping to engines with a gate valve and union and flexible connector.
   1. Natural-gas piping, valves, and specialties for gas distribution are specified in Section 15505 "Fuel Piping."
   2. Install manual shutoff valve in a remote location to isolate natural-gas supply to the generator enclosure.
   3. Vent gas pressure regulators outside building a minimum of 60 inches from building openings.
E. Ground equipment according to Section 16170 "Grounding and Bonding."
F. Balance single-phase loads to obtain a maximum of 10 percent unbalance between any two phases.

3.5 IDENTIFICATION

A. Install a sign indicating the generator neutral is bonded to the main service neutral at the main service location.

3.6 FIELD QUALITY CONTROL

A. Testing Agency: At the owner's request, the contractor shall engage a qualified, third-party, testing agency to witness tests and inspections.
B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
C. Perform tests and inspections.
    1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections.
D. Tests and Inspections:
    1. Perform tests recommended by manufacturer and each visual and mechanical inspection and electrical and mechanical test listed in the first two subparagraphs as specified in NETA Acceptance Testing Specification. Certify compliance with test parameters.
        a. Visual and Mechanical Inspection
            1) Compare equipment nameplate data with drawings and specifications.
            2) Inspect physical and mechanical condition.
            3) Inspect anchorage, alignment, and grounding.
            4) Verify the unit is clean.
        b. Electrical and Mechanical Tests
            1) Test protective relay devices per manufacturer recommendations.
            2) Verify phase rotation, phasing, and synchronized operation as required by the application.
            3) Functionally test engine shutdown for low oil pressure, over-temperature, over-speed, and other protection features as applicable.
            4) Conduct performance test in accordance with NFPA 110.
            5) Verify correct functioning of the governor and regulator.
    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. Provide portable load bank for 4-hour full load test.
    4. 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.
    5. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
    6. 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.
    7. Voltage and Frequency Transient Stability Tests: Use data capture from manufacturer control panel and software to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases and verify that performance is as specified.
E. Coordinate tests with tests for transfer switches and run them concurrently.
F. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.
G. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
H. Remove and replace malfunctioning units and retest as specified above.
I. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

J. 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.

3.7 MAINTENANCE SERVICE

A. Retain this article for critical installations and consider including a provision for submitting a continuing maintenance agreement proposal. Revise starting date if required. Obtain a copy of maintenance agreement before retaining or editing below. Maintenance contracts may not be allowed for publicly funded projects.

B. Initial Maintenance Service: Beginning at Substantial Completion, provide 12 months' full maintenance by EGSA Certified employees of manufacturer's designated service organization. Include quarterly exercising to check for proper starting, load transfer, and running under load. Include routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Provide parts and supplies same as those used in the manufacture and installation of original equipment.

END OF SECTION

SECTION 16705

CONDUIT ROUGH-IN FOR SPECIAL SYSTEMS

PART 1 – GENERAL

1.1 RELATED DOCUMENTS
A. Drawings and general provisions of Contract, including General and Supplementary Conditions and the General Requirement Specification Sections, apply to this Section.
B. This section is hereby made a part of all other sections of Division 16 as fully as if repeated in each therein.

1.2 DESCRIPTION
A. Furnish and install Conduit Rough-In systems including all work incidental thereto as shown on Drawings and specified.
B. This section is applicable to data/voice, and security systems.
C. This section covers steel Tele-Power Pole Systems used to extend branch circuit wiring and/or data network, voice, and other communication cabling to points of use as shown on the building plans. The Tele-Power Pole System shall consist of the Tele-Power Pole Multioutlet Assembly, Appropriate fittings and accessories to complete the installation per the electrical and/or communication drawings.

1.3 SUBMITTALS
A. Shop drawings are not required for material and equipment specified under this section of the specifications.

PART 2 – PRODUCTS

2.1 OUTLET BOXES
A. Two gang for data, voice, cable TV, CCTV, card reader and sound system devices.

2.2 PLASTER COVER RINGS
A. Single gang for single device, double gang for two devices, etc.

2.3 COVER PLATES
A. Cover plates for data, voice, cable TV, CCTV, card reader and sound systems shall be provided by its respective trade.

2.4 RACEWAYS
A. Per appropriate section with insulated throat bushings on all conduit runs and rubber grommeted holes between boxes or box sections. Provide pull strings.

PART 3 – EXECUTION

3.1 COORDINATION
A. Comply with all requirements of the Owner's representative for all raceways, boxes, cover plates, etc., and their specific installation considerations.
B. Consult with Owner's representative prior to installation to determine special raceway requirements for all data, telephone, cable TV, CCTV, card reader and sound systems.

3.2 INSTALLATION
A. Furnish and install the trunk raceways, outlet box, and outlet box raceways as shown on drawings and specified.
B. Install trunk raceways to within six inches of backboards.
C. Stub outlet box raceways to cable support system provided by others within accessible ceiling cavity.
D. Minimum outlet box conduit sizes shall be 1-inch.

E. In each instance where two or more device boxes are generally located in the same vicinity and at the same mounting height, mount those devices in a common multi-gang barrier box appropriate for the device types.
F. Mark each conduit end for identification and destination of raceway.
G. Provide required sleeves in all walls and floors as required by low voltage system contractors.
H. Provide pull rope in each raceway.
I. Provide insulating bus wings and locknuts for all raceways.
J. There shall not be more than the equivalent of three 90-degree bends in any single run of conduit between boxes or fittings.
K. Bends shall be made so that the conduit will not be flattened or kinked and the internal diameter of the conduit will not be reduced.
L. The radius of the curve of the inner edge of any bend shall not be less than as indicated by the National Electrical Code and ANSI/TIA/EIA 569A Commercial Building Standard for Telecommunications Pathways and Spaces.
M. In no case shall any conduit be bent or any fabricated elbow be applied no less than the allowable bending radius as specified by the cable manufacturer of the installed conductor.
N. Provide blank cover plates for each unused outlet box.
O. Prior to and during installation of Tele-Power Pole System refer to system layout or approval drawings containing all elements of the system. Installer shall comply with detailed manufacturer's instruction sheets, which accompany system components, as well as complete system instruction sheets, whichever is applicable.
P. All raceway systems shall be mechanically continuous and connected to all electrical outlets, boxes, device mounting brackets, and cabinets, also in accordance with manufacturer's installation sheets.
Q. All metal raceway shall be electrically continuous and bonded in accordance with the National Electric Code for proper grounding.
R. Raceway shall be securely supported at intervals not exceeding 5' [1.5m] or in accordance with manufacturer's installation sheets.
S. All Tele-Power Pole Systems shall be installed complete in accordance with the manufacturer's installation sheets. All unused openings shall be closed.

END OF SECTION

SECTION 16722

FIRE ALARM SYSTEM MASS NOTIFICATION CONTROL PANEL

PART 1 - GENERAL

1.1 DESCRIPTION:

A. This section of the specification includes the furnishing, installation, connection, and testing of the microprocessor-controlled Voice Evacuation/Mass Notification control panel.

B. The Voice Evacuation/Mass Notification panel shall comply with NFPA 72 requirements.
   1. The Secondary Power Source of the Voice Evacuation/Mass Notification panel will be capable of providing at least 24 hours of backup power with the ability to sustain 15 minutes in alarm at the end of the backup period.

C. The Voice Evacuation/Mass Notification panel shall be manufactured by an ISO 9001 certified company and meet the requirements of BS EN9001: ANSI/ASQC Q9001-1994.

D. The Voice Evacuation/Mass Notification panel and peripheral devices shall be manufactured 100% by a single U.S. manufacturer (or division thereof).

E. Underwriters Laboratories Inc. (UL) - USA:
   1. UL 864 Standard for Control Units for Fire Protective Signaling Systems
   2. UL 1711 Amplifiers for Fire Protective Signaling Systems
   3. UL 2572 Communication and Control Units for Mass Notification Systems Other:
   4. NEC Article 250 Grounding
   5. NEC Article 300 Wiring Methods
   6. NEC Article 760 Fire Protective Signaling Systems
   7. Compliant with Unified Facilities Criteria UFC 4-021-01

F. The Voice Evacuation/Mass Notification panel shall be ANSI 864, 9th Edition Listed. Systems listed to ANSI 864, 8th edition (or previous revisions) shall not be accepted.

G. The installing company shall employ NICET (minimum Level II Fire Alarm Technology) technicians on site to guide the final check-out and to ensure the systems integrity.

1.2 SCOPE:

A. A microprocessor-controlled Voice Evacuation/Mass Notification control panel shall be installed in accordance with the project specifications and drawings.

1.3 SUBMITTALS

A. General:
   1. Two copies of all submittals shall be submitted to the Architect/Engineer for review.
   2. All references to manufacturer's model numbers and other pertinent information herein is intended to establish minimum standards of performance, function and quality. Equivalent compatible UL-listed equipment from other manufacturers may be substituted for the specified equipment as long as the minimum standards are met.
   3. For equipment other than that specified, the contractor shall supply proof that such substitute equipment equals or exceeds the features, functions, performance, and quality of the specified equipment.

B. Shop Drawings:
   1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
   2. Include manufacturer's name(s), model numbers, ratings, power requirements, equipment layout, device arrangement, complete wiring point-to-point diagrams, and conduit layouts.
   3. Show system layout, configurations, and terminations.

C. Manuals:
   1. Submit simultaneously with the shop drawings, complete operating and maintenance manuals listing the manufacturer's name(s), including technical data sheets.
   2. Wiring diagrams shall indicate internal wiring for each device and the interconnections between the items of equipment.
   3. Provide a clear and concise description of operation that gives, in detail, the information required to properly operate the equipment and system.

D. Software Modifications

1. Provide the services of a qualified technician to perform all system software modifications, upgrades, or changes. Response time of the technician to the site shall not exceed 4 hours.
2. Provide all hardware, software, programming tools and documentation necessary to modify the Voice Evacuation/Mass Notification Control Panel on site. Modification includes addition and deletion of messages, circuits, zones, and changes to system operation. The system structure and software shall place no limit on the type or extent of software modifications on-site.

1.4 GUARANTY:

A. All work performed and all material and equipment furnished under this contract shall be free from defects and shall remain so for a period of at least one (1) year from the date of acceptance. The full cost of maintenance, labor and materials required to correct any defect during this one-year period shall be included in the submittal bid.

1.5 MAINTENANCE:

A. Maintenance and testing shall be on a semi-annual schedule or as required by the local AHJ. A preventive maintenance schedule shall be provided by the contractor describing the protocol for preventive maintenance. The Voice Evacuation/Mass Notification Control Panel shall be tested in accordance with the requirements of NFPA 72.
B. As part of the bid/proposal, include a quote for a maintenance contract to provide all maintenance, tests, and repairs described below. Include also a quote for unscheduled maintenance/repairs, including hourly rates for technicians trained on this equipment, and response travel costs for each year of the maintenance period. Submittals that do not identify all post contract maintenance costs will not be accepted. Rates and costs shall be valid for the period of five (5) years after expiration of the guaranty.

1.6 POST CONTRACT EXPANSIONS:

A. The contractor shall have the ability to provide parts and labor to expand the system specified, if so requested, for a period of five (5) years from the date of acceptance.
B. As part of the submittal, include a quotation for all parts and material, and all installation and test labor as needed to increase the number of speakers zones or wattage by ten percent (10%).
C. The quotation shall include installation, test labor, and labor to reprogram the system for this 10% expansion. If additional Voice Evacuation/Mass Notification Control Panel hardware is required, include the material and labor necessary to install this hardware.
D. Do not include cost of conduit or wire or the cost to install conduit or wire except for labor to make final connections at the Voice Evacuation/Mass Notification Control Panel.
E. Submittals that do not include this estimate of post contract expansion cost will not be accepted.

1.7 APPLICABLE STANDARDS AND SPECIFICATIONS:

A. The specifications and standards listed below form a part of this specification. The system shall fully comply with the latest issue of these standards, if applicable.
    1. National Fire Protection Association (NFPA) - USA:
        a. No. 70: National Electric Code (NEC)
        b. No. 72: National Fire Alarm Code
        c. No. 101: Life Safety Code
B. The system and its components shall be Underwriters Laboratories, Inc. listed under the appropriate UL testing standard as listed herein for fire alarm applications and the installation shall be in compliance with the UL listing.
C. Local and State Building Codes.
D. All requirements of the Authority Having Jurisdiction (AHJ).

1.8 APPROVALS:

A. The system shall have proper listing and/or approval from the following nationally recognized agencies:
   1. UL Underwriters Laboratories Inc (Ninth Edition)
   2. CSFM California State Fire Marshal
   3. MEA Material Equipment Acceptance (NYFD COA)

PART 2 - PRODUCTS

2.1 EQUIPMENT AND MATERIAL, GENERAL:

A. All equipment and components shall be new, and the manufacturer's current model. The materials, appliances, equipment, and devices shall be tested and listed by a nationally recognized approvals agency for use as part of a fire protective signaling system, meeting the National Fire Alarm Code.
B. All equipment and components shall be installed in strict compliance with manufacturers' recommendations. Consult the manufacturer's installation manuals for all wiring diagrams, schematics, physical equipment sizes, etc., before beginning system installation.
C. All equipment shall be attached to walls and ceiling/floor assemblies and shall be held firmly in place (e.g., speakers shall not be supported solely by suspended ceilings). Fasteners and supports shall be adequate to support the required load.
D. All equipment must be available "over the counter" through the Security Equipment Distributor (SED) market and can be installed by dealerships independent of the manufacturer.

2.2 CONDUIT AND WIRE:

A. Conduit:
   1. Conduit shall be in accordance with The National Electrical Code (NEC), local and state requirements.
   2. Where required, all wiring shall be installed in conduit or raceway. Conduit fill shall not exceed 40 percent of interior cross-sectional area where three or more cables are contained within a single conduit.
   3. Cable must be separated from any open conductors of power, or Class 1 circuits, and shall not be placed in any conduit, junction box or raceway containing these conductors, per NEC Article 760.
   4. All circuits shall be provided with transient suppression devices and the system shall be designed to permit simultaneous operation of all circuits without interference or loss of signals.
   5. Conduit shall not enter the Voice Evacuation/Mass Notification Control Panel, or any other remotely mounted panel equipment or backboxes, except where conduit entry is specified by the Voice Evacuation/Mass Notification Control Panel manufacturer.
   6. Conduit shall be 3/4-inch (19.1 mm) minimum.
B. Wire:
   1. All Voice Evacuation/Mass Notification Control Panel wiring shall be new.
   2. Wiring shall be in accordance with local, state, and national codes (e.g., NEC Article 760) and as recommended by the manufacturer of the Voice Evacuation/Mass Notification Control Panel. Number and size of conductors shall be as recommended by the Voice Evacuation/Mass Notification Control Panel, but not less 14 AWG (1.63 mm) for Notification Appliance Circuits.
   3. All wire and cable shall be listed and/or approved by a recognized testing agency for use with a protective signaling system.
   4. Wire and cable not installed in conduit shall have a fire resistance rating suitable for the installation as indicated in NEC 760 (e.g., FPLR).
   5. All field wiring shall be electrically supervised for open circuit and ground fault.
C. Terminal Boxes, Junction Boxes and Cabinets:
   1. All boxes and cabinets shall be UL listed for their use and purpose.

D. The Voice Evacuation/Mass Notification Control Panel shall be connected to a separate dedicated branch circuit, maximum 20 amperes. This circuit shall be labeled at the main power distribution panel as Voice Evacuation/Mass Notification Control Panel. Voice Evacuation/Mass Notification Control Panel primary power wiring shall be 12 AWG. The panel cabinet shall be grounded securely to either a cold-water pipe or grounding rod.
   1. The Voice Evacuation/Mass Notification Control Panel notification circuit (NACs 1) shall also automatically synchronize any of the following manufacturer's notification appliances connected to them: System Sensor, Wheelock, or Gentex with no need for additional synchronization modules.

2.3 Voice Evacuation/Mass Notification Control Panel:

A. The Voice Evacuation/Mass Notification Control Panel shall be a Fire-Lite Alarms ECC-50/100 (Emergency Command Center) and shall contain a microprocessor-based Central Processing Unit (CPU). The CPU shall distribute and control emergency voice messages over the speaker circuits.

B. The system shall provide the capability to interface to LOC (Local Operator Console), Distributed Audio Amplifiers, Remote Page Unit, Remote Microphone, Fire Fighter Telephone Unit and Remote Telephone Zone Module from the same manufacturer.

C. Shall have as minimum requirements:
   1. Integral 50 Watt, 25 Vrms audio amplifier with optional converter for 70.7-volt systems. The system shall be capable of expansion to 100 watts total via the insertion of an additional 50-watt audio amplifier module (can be used as a backup amplifier) into the same cabinet and expandable over 1100 watts.
   2. Speaker circuit that can be wired both Class A and B.
   3. Integral Digital Message Generator with a memory capacity for up to 60 seconds per messaging. The Digital Message Generator shall be capable of producing fourteen distinct messages (60 seconds each). Field-selectable message and custom message recording capability using the local microphone, a USB port, or an external audio input.
   4. Built in alert tone patterns with ANSI, March Code, California, Steady, Alert Tone, Hi-Lo, ANSI Whoop, Continuous Whoop, or No Tone is field programmable. Tone Prior to transmitting a message, the Voice Evacuation/Mass Notification Control Panel can be programmed to produce a pre-announce and post-announce tone.
      a. Leading Tone Duration If a pre-announce tone is desired, select the length of time it will play before a message is broadcasted. Select 4, 8, 12, 16, 20, 24, or 28 seconds. In a pre-announce tone is not desired, select 0 seconds.
      b. Trailing Tone Duration Select the length of time for the post-message announcement tone. Select 4, 8, 12, 16, 20, 24, 28, or 32 seconds from the drop-down menu.
      c. Repeat Cycle Select the number of times the message will be repeated during an alarm. A message can be repeated 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, or an Infinite amount of times.
   5. The Voice Evacuation/Mass Notification Control Panel will be capable of detecting and annunciating the following conditions: Loss of Power (AC and DC), System Trouble, Ground Fault, Alarm, Microphone Trouble, Message Generator Trouble, Tone Generator Trouble, and Amplifier Fault.
   6. The Voice Evacuation/Mass Notification Control Panel shall be fully supervised including microphone, amplifier output, message generator, speaker wiring, and tone generation.
   7. Speaker outputs shall be fully power-limited.
   8. Amplifiers will be supplied power independently to eliminate a short on one circuit from affecting other circuits.
   9. The Voice Evacuation/Mass Notification Control Panel will provide full supervision on both active (alarm or music) and standby conditions.
   10. An optional zone splitter version shall be available that permits splitting speaker circuits into 8 specific zones.
   11. An optional distributed amplifiers unit shall be available that permits splitting speaker circuits up to a total of 24 speaker zones.

12. Wiring terminals shall be removable terminal blocks (Wire Gauge 12 – 18 AWG) for ease of servicing.
13. Voice Evacuation/Mass Notification Control Panel will provide 2 amp Notification Appliance Circuit (NAC) output with sync generator or follower for System Sensor, Wheelock or Gentex protocols. The NAC shall be capable of One (1) Style Y (Class B) or Style Z (Class A) circuit.
14. Shall have eight Command Input Circuits to activate messages via reverse polarity or contact closures.
15. Built in External Audio Input can be used for background music.
16. On-board battery charger which supports charging up to 26 AH batteries (cabinet holds up to 18AH batteries).
17. Programmable delay of immediate, 2 hours or 6 hours reporting of AC Loss.
18. Built in Piezo sounder for local trouble.
19. Stores the events in the 100 Event History log
20. Shall have Console Lamp Test switch and shall activate all system LEDs including Remote Consoles.
21. Shall have three Form-C relays:
    a. AC Power Loss Relay
    b. System Trouble Relay
    c. MNS Active (For Mass Notification signage)
22. Shall have a Special Application (auxiliary power) output for addressable modules when interfaced with compatible addressable FACPs and End-of-Line power supervision relays.
23. Shall be capable of Speaker Volume Control. The Supervised Volume Control will allow manual volume setting for telephone paging and background music for a specific speaker or speaker zone.
24. Shall have a Night Ring input allows a building's Private Branch Exchange (PBX) to activate the Voice Evacuation/Mass Notification panel.
25. The Voice Evacuation/Mass Notification panel can communicate in any combination up to eight (8) external remote consoles:
    a. Optional Remote Microphone
    b. Optional Remote Page Unit
    c. Optional Local Operator Console
26. The Voice Evacuation/Mass Notification panel can communicate in any combination up to eight (8) external distributed audio amplifiers:
    a. Optional Distributed Amplifier, 50 watts.
    b. Optional Distributed Amplifier, 125 watts.
27. Shall be capable of integrating with firefighter telephone system that provides secure and reliable communications. The firefighter telephone system will allow for up to ten users to plug in to a remote telephone jack and communicate simultaneously within a building.
28. Shall be capable of secure access to the Voice Evacuation/Mass Notification panel via cell phone or other remote telephone.
29. The Voice Evacuation/Mass Notification panel can be integrated by an FACP via the ANN/ACS (EIA-485) link. Compatible FACPs include the MS-9200UDLS and MS-9600(UD)LS.
30. The Voice Evacuation/Mass Notification panel integrates with the MS-9200UDLS and MS-9600(UD)LS will report Mass Notification events to the Central Station.
31. The Voice Evacuation/Mass Notification panel can be interface with other UL Listed Fire Alarm Control Panels via activation of reverse polarity or by contact closure.

D. Speakers:
1. All speakers shall operate on 25 or 70 VRMS with field selectable output taps from 0.25 to 2.0 Watts.
2. Speakers in corridors and public spaces shall produce a minimum sound level of 75 dBA output at 10 feet (3m).
3. The plug-in speaker allows the installer to pre-wire mounting plates and dress the wires before plugging in the speakers.

4. Flush mount applications are achievable without the need for an extension ring.
5. Frequency response shall be a minimum of 400 HZ to 4000 HZ.
6. Rotary switch simplifies field selection of speaker voltage and power settings.

E. Enclosures:
1. The Voice Evacuation/Mass Notification panel shall be housed in a UL-listed cabinet suitable for surface mounting. The cabinet and front shall be corrosion protected and painted red via the powder coat method with manufacturer's standard finish.
2. The back box and door shall be constructed of steel with provisions for electrical conduit connections into the sides and top.
3. The door shall provide a key lock and shall provide for the viewing of all indicators.

F. Power Supply:
1. The main power supply for the Voice Evacuation/Mass Notification panel shall provide up to 7.5 amps of available power for the panel and peripheral devices.
2. Provisions will be made to allow the audio-visual power to be increased as required by adding modular expansion audio-visual power supplies.
3. The power supply shall provide an integral battery charger or may be used with an external battery and charger systems. Battery arrangement may be configured in the field.
4. The main power supply shall continuously monitor all field wires for earth ground conditions.
5. The main power supply shall operate on 120 VAC, 60 Hz or 240 VAC, 50 Hz, and shall provide all necessary power for the Voice Evacuation/Mass Notification panel.

G. BATTERIES:
1. Upon loss of Primary (AC) power to the Voice Evacuation/Mass Notification panel, the batteries shall have sufficient capacity to power the Voice Evacuation/Mass Notification panel for required standby time (24 or 60 hours) followed by 15 minutes of alarm.
2. The batteries are to be completely maintenance free. No liquids are required. Fluid level checks for refilling, spills, and leakage shall not be required.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. Installation shall be in accordance with the NEC, NFPA 72, local and state codes, as shown on the drawings, and as recommended by the major equipment manufacturer.

B. All conduit, junction boxes, conduit supports and hangers shall be concealed in finished areas and may be exposed in unfinished areas. Smoke detectors shall not be installed prior to the system programming and test period. If construction is ongoing during this period, measures shall be taken to protect speakers from contamination and physical damage.

3.2 TEST:

A. The service of a competent, factory-trained engineer or technician authorized by the manufacturer of the fire alarm equipment shall be provided to technically supervise and participate during all of the adjustments and tests for the system. All testing shall be in accordance with NFPA 72.
1. Before energizing the cables and wires, check for correct connections and test for short circuits, ground faults, continuity, and insulation.
2. Open and short notification appliance circuits and verify that trouble signal actuates.
3. Ground all circuits and verify response of trouble signals.
4. Check presence and audibility of tone at all alarm notification devices.
5. When the system is equipped with optional features, the manufacturer's manual shall be consulted to determine the proper testing procedures. This is intended to address such items as verifying voice messages.

3.3 FINAL INSPECTION:

A. At the final inspection a minimum NICET Level II technician shall demonstrate that the system functions properly in every respect.

3.4 INSTRUCTION:

A. Instruction shall be provided as required for operating the system. Hands-on demonstrations of the operation of all system components and the entire system including program changes and functions shall be provided.

B. The contractor or installing dealer shall provide a user manual indicating "Sequence of Operation."

END OF SECTION

SECTION 16725

EMERGENCY VOICE EVACUATION/MASS NOTIFICATION CONTROL PANEL

PART 1 - GENERAL

1.1 DESCRIPTION:

A. This section of the specification includes the furnishing, installation, connection, and testing of the microprocessor-controlled Voice Evacuation/Mass Notification control panel.

B. The Voice Evacuation/Mass Notification panel shall comply with NFPA 72 requirements.
   1. The Secondary Power Source of the Voice Evacuation/Mass Notification panel will be capable of providing at least 24 hours of backup power with the ability to sustain 15 minutes in alarm at the end of the backup period.

C. The Voice Evacuation/Mass Notification panel shall be manufactured by an ISO 9001 certified company and meet the requirements of BS EN9001: ANSI/ASQC Q9001-1994.

D. The Voice Evacuation/Mass Notification panel and peripheral devices shall be manufactured 100% by a single U.S. manufacturer (or division thereof).

E. Underwriters Laboratories Inc. (UL) - USA:
   1. UL 864 Standard for Control Units for Fire Protective Signaling Systems
   2. UL 1711 Amplifiers for Fire Protective Signaling Systems
   3. UL 2572 Communication and Control Units for Mass Notification Systems Other:
   4. NEC Article 250 Grounding
   5. NEC Article 300 Wiring Methods
   6. NEC Article 760 Fire Protective Signaling Systems
   7. Compliant with Unified Facilities Criteria UFC 4-021-01

F. The Voice Evacuation/Mass Notification panel shall be ANSI 864, 9th Edition Listed. Systems listed to ANSI 864, 8th edition (or previous revisions) shall not be accepted.

G. The installing company shall employ NICET (minimum Level II Fire Alarm Technology) technicians on site to guide the final check-out and to ensure the systems integrity.

1.2 SCOPE:

A. A microprocessor-controlled Voice Evacuation/Mass Notification control panel shall be installed in accordance with the project specifications and drawings.

1.3 SUBMITTALS

A. General:
   1. Two copies of all submittals shall be submitted to the Architect/Engineer for review.
   2. All references to manufacturer's model numbers and other pertinent information herein is intended to establish minimum standards of performance, function and quality. Equivalent compatible UL-listed equipment from other manufacturers may be substituted for the specified equipment as long as the minimum standards are met.
   3. For equipment other than that specified, the contractor shall supply proof that such substitute equipment equals or exceeds the features, functions, performance, and quality of the specified equipment.

B. Shop Drawings:
   1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
   2. Include manufacturer's name(s), model numbers, ratings, power requirements, equipment layout, device arrangement, complete wiring point-to-point diagrams, and conduit layouts.
   3. Show system layout, configurations, and terminations.

C. Manuals:
   1. Submit simultaneously with the shop drawings, complete operating and maintenance manuals listing the manufacturer's name(s), including technical data sheets.
   2. Wiring diagrams shall indicate internal wiring for each device and the interconnections between the items of equipment.
   3. Provide a clear and concise description of operation that gives, in detail, the information required to properly operate the equipment and system.

D. Software Modifications
   1. Provide the services of a qualified technician to perform all system software modifications, upgrades, or changes. Response time of the technician to the site shall not exceed 4 hours.
   2. Provide all hardware, software, programming tools and documentation necessary to modify the Voice Evacuation/Mass Notification Control Panel on site. Modification includes addition and deletion of messages, circuits, zones, and changes to system operation. The system structure and software shall place no limit on the type or extent of software modifications on-site.

1.4 GUARANTY:

A. All work performed and all material and equipment furnished under this contract shall be free from defects and shall remain so for a period of at least one (1) year from the date of acceptance. The full cost of maintenance, labor and materials required to correct any defect during this one-year period shall be included in the submittal bid.

1.5 MAINTENANCE:

A. Maintenance and testing shall be on a semi-annual schedule or as required by the local AHJ. A preventive maintenance schedule shall be provided by the contractor describing the protocol for preventive maintenance. The Voice Evacuation/Mass Notification Control Panel shall be tested in accordance with the requirements of NFPA 72.
B. As part of the bid/proposal, include a quote for a maintenance contract to provide all maintenance, tests, and repairs described below. Include also a quote for unscheduled maintenance/repairs, including hourly rates for technicians trained on this equipment, and response travel costs for each year of the maintenance period. Submittals that do not identify all post contract maintenance costs will not be accepted. Rates and costs shall be valid for the period of five (5) years after expiration of the guaranty.

1.6 POST CONTRACT EXPANSIONS:

A. The contractor shall have the ability to provide parts and labor to expand the system specified, if so requested, for a period of five (5) years from the date of acceptance.
B. As part of the submittal, include a quotation for all parts and material, and all installation and test labor as needed to increase the number of speakers zones or wattage by ten percent (10%).
C. The quotation shall include installation, test labor, and labor to reprogram the system for this 10% expansion. If additional Voice Evacuation/Mass Notification Control Panel hardware is required, include the material and labor necessary to install this hardware.
D. Do not include cost of conduit or wire or the cost to install conduit or wire except for labor to make final connections at the Voice Evacuation/Mass Notification Control Panel.
E. Submittals that do not include this estimate of post contract expansion cost will not be accepted.

1.7 APPLICABLE STANDARDS AND SPECIFICATIONS:

A. The specifications and standards listed below form a part of this specification. The system shall fully comply with the latest issue of these standards, if applicable.
   1. National Fire Protection Association (NFPA) - USA:
      a. No. 70: National Electric Code (NEC)
      b. No. 72: National Fire Alarm Code
      c. No. 101: Life Safety Code
B. The system and its components shall be Underwriters Laboratories, Inc. listed under the appropriate UL testing standard as listed herein for fire alarm applications and the installation shall be in compliance with the UL listing.
C. Local and State Building Codes.
D. All requirements of the Authority Having Jurisdiction (AHJ).

1.8 APPROVALS:

A. The system shall have proper listing and/or approval from the following nationally recognized agencies:
   1. UL Underwriters Laboratories Inc (Ninth Edition)
   2. CSFM California State Fire Marshal
   3. MEA Material Equipment Acceptance (NYFD COA)

PART 2 - PRODUCTS

2.1 EQUIPMENT AND MATERIAL, GENERAL:

A. All equipment and components shall be new, and the manufacturer's current model. The materials, appliances, equipment, and devices shall be tested and listed by a nationally recognized approvals agency for use as part of a fire protective signaling system, meeting the National Fire Alarm Code.
B. All equipment and components shall be installed in strict compliance with manufacturers' recommendations. Consult the manufacturer's installation manuals for all wiring diagrams, schematics, physical equipment sizes, etc., before beginning system installation.
C. All equipment shall be attached to walls and ceiling/floor assemblies and shall be held firmly in place (e.g., speakers shall not be supported solely by suspended ceilings). Fasteners and supports shall be adequate to support the required load.
D. All equipment must be available "over the counter" through the Security Equipment Distributor (SED) market and can be installed by dealerships independent of the manufacturer.

2.2 CONDUIT AND WIRE:

A. Conduit:
   1. Conduit shall be in accordance with The National Electrical Code (NEC), local and state requirements.
   2. Where required, all wiring shall be installed in conduit or raceway. Conduit fill shall not exceed 40 percent of interior cross-sectional area where three or more cables are contained within a single conduit.
   3. Cable must be separated from any open conductors of power, or Class 1 circuits, and shall not be placed in any conduit, junction box or raceway containing these conductors, per NEC Article 760.
   4. All circuits shall be provided with transient suppression devices and the system shall be designed to permit simultaneous operation of all circuits without interference or loss of signals.
   5. Conduit shall not enter the Voice Evacuation/Mass Notification Control Panel, or any other remotely mounted panel equipment or backboxes, except where conduit entry is specified by the Voice Evacuation/Mass Notification Control Panel manufacturer.
   6. Conduit shall be 3/4-inch (19.1 mm) minimum.
B. Wire:
   1. All Voice Evacuation/Mass Notification Control Panel wiring shall be new.
   2. Wiring shall be in accordance with local, state, and national codes (e.g., NEC Article 760) and as recommended by the manufacturer of the Voice Evacuation/Mass Notification Control Panel. Number and size of conductors shall be as recommended by the Voice Evacuation/Mass Notification Control Panel, but not less 14 AWG (1.63 mm) for Notification Appliance Circuits.
   3. All wire and cable shall be listed and/or approved by a recognized testing agency for use with a protective signaling system.
   4. Wire and cable not installed in conduit shall have a fire resistance rating suitable for the installation as indicated in NEC 760 (e.g., FPLR).
   5. All field wiring shall be electrically supervised for open circuit and ground fault.
C. Terminal Boxes, Junction Boxes and Cabinets:
   1. All boxes and cabinets shall be UL listed for their use and purpose.

D. The Voice Evacuation/Mass Notification Control Panel shall be connected to a separate dedicated branch circuit, maximum 20 amperes. This circuit shall be labeled at the main power distribution panel as Voice Evacuation/Mass Notification Control Panel. Voice Evacuation/Mass Notification Control Panel primary power wiring shall be 12 AWG. The panel cabinet shall be grounded securely to either a cold-water pipe or grounding rod.
   1. The Voice Evacuation/Mass Notification Control Panel notification circuit (NACs 1) shall also automatically synchronize any of the following manufacturer's notification appliances connected to them: System Sensor, Wheelock, or Gentex with no need for additional synchronization modules.

2.3 Voice Evacuation/Mass Notification Control Panel:

A. The Voice Evacuation/Mass Notification Control Panel shall be a Fire-Lite Alarms ECC-50/100 (Emergency Command Center) and shall contain a microprocessor-based Central Processing Unit (CPU). The CPU shall distribute and control emergency voice messages over the speaker circuits.

B. The system shall provide the capability to interface to LOC (Local Operator Console), Distributed Audio Amplifiers, Remote Page Unit, Remote Microphone, Fire Fighter Telephone Unit and Remote Telephone Zone Module from the same manufacturer.

C. Shall have as minimum requirements:
   1. Integral 50 Watt, 25 Vrms audio amplifier with optional converter for 70.7-volt systems. The system shall be capable of expansion to 100 watts total via the insertion of an additional 50-watt audio amplifier module (can be used as a backup amplifier) into the same cabinet and expandable over 1100 watts.
   2. Speaker circuit that can be wired both Class A and B.
   3. Integral Digital Message Generator with a memory capacity for up to 60 seconds per messaging. The Digital Message Generator shall be capable of producing fourteen distinct messages (60 seconds each). Field-selectable message and custom message recording capability using the local microphone, a USB port, or an external audio input.
   4. Built in alert tone patterns with ANSI, March Code, California, Steady, Alert Tone, Hi-Lo, ANSI Whoop, Continuous Whoop, or No Tone is field programmable. Tone Prior to transmitting a message, the Voice Evacuation/Mass Notification Control Panel can be programmed to produce a pre-announce and post-announce tone.
      a. Leading Tone Duration If a pre-announce tone is desired, select the length of time it will play before a message is broadcasted. Select 4, 8, 12, 16, 20, 24, or 28 seconds. In a pre-announce tone is not desired, select 0 seconds.
      b. Trailing Tone Duration Select the length of time for the post-message announcement tone. Select 4, 8, 12, 16, 20, 24, 28, or 32 seconds from the drop-down menu.
      c. Repeat Cycle Select the number of times the message will be repeated during an alarm. A message can be repeated 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, or an Infinite amount of times.
   5. The Voice Evacuation/Mass Notification Control Panel will be capable of detecting and annunciating the following conditions: Loss of Power (AC and DC), System Trouble, Ground Fault, Alarm, Microphone Trouble, Message Generator Trouble, Tone Generator Trouble, and Amplifier Fault.
   6. The Voice Evacuation/Mass Notification Control Panel shall be fully supervised including microphone, amplifier output, message generator, speaker wiring, and tone generation.
   7. Speaker outputs shall be fully power-limited.
   8. Amplifiers will be supplied power independently to eliminate a short on one circuit from affecting other circuits.
   9. The Voice Evacuation/Mass Notification Control Panel will provide full supervision on both active (alarm or music) and standby conditions.
   10. An optional zone splitter version shall be available that permits splitting speaker circuits into 8 specific zones.
   11. An optional distributed amplifiers unit shall be available that permits splitting speaker circuits up to a total of 24 speaker zones.

12. Wiring terminals shall be removable terminal blocks (Wire Gauge 12 – 18 AWG) for ease of servicing.
13. Voice Evacuation/Mass Notification Control Panel will provide 2 amp Notification Appliance Circuit (NAC) output with sync generator or follower for System Sensor, Wheelock or Gentex protocols. The NAC shall be capable of One (1) Style Y (Class B) or Style Z (Class A) circuit.
14. Shall have eight Command Input Circuits to activate messages via reverse polarity or contact closures.
15. Built in External Audio Input can be used for background music.
16. On-board battery charger which supports charging up to 26 AH batteries (cabinet holds up to 18AH batteries).
17. Programmable delay of immediate, 2 hours or 6 hours reporting of AC Loss.
18. Built in Piezo sounder for local trouble.
19. Stores the events in the 100 Event History log
20. Shall have Console Lamp Test switch and shall activate all system LEDs including Remote Consoles.
21. Shall have three Form-C relays:
    a. AC Power Loss Relay
    b. System Trouble Relay
    c. MNS Active (For Mass Notification signage)
22. Shall have a Special Application (auxiliary power) output for addressable modules when interfaced with compatible addressable FACPs and End-of-Line power supervision relays.
23. Shall be capable of Speaker Volume Control. The Supervised Volume Control will allow manual volume setting for telephone paging and background music for a specific speaker or speaker zone.
24. Shall have a Night Ring input allows a building's Private Branch Exchange (PBX) to activate the Voice Evacuation/Mass Notification panel.
25. The Voice Evacuation/Mass Notification panel can communicate in any combination up to eight (8) external remote consoles:
    a. Optional Remote Microphone
    b. Optional Remote Page Unit
    c. Optional Local Operator Console
26. The Voice Evacuation/Mass Notification panel can communicate in any combination up to eight (8) external distributed audio amplifiers:
    a. Optional Distributed Amplifier, 50 watts.
    b. Optional Distributed Amplifier, 125 watts.
27. Shall be capable of integrating with firefighter telephone system that provides secure and reliable communications. The firefighter telephone system will allow for up to ten users to plug in to a remote telephone jack and communicate simultaneously within a building.
28. Shall be capable of secure access to the Voice Evacuation/Mass Notification panel via cell phone or other remote telephone.
29. The Voice Evacuation/Mass Notification panel can be integrated by an FACP via the ANN/ACS (EIA-485) link. Compatible FACPs include the MS-9200UDLS and MS-9600(UD)LS.
30. The Voice Evacuation/Mass Notification panel integrates with the MS-9200UDLS and MS-9600(UD)LS will report Mass Notification events to the Central Station.
31. The Voice Evacuation/Mass Notification panel can be interface with other UL Listed Fire Alarm Control Panels via activation of reverse polarity or by contact closure.

D. Speakers:
1. All speakers shall operate on 25 or 70 VRMS with field selectable output taps from 0.25 to 2.0 Watts.
2. Speakers in corridors and public spaces shall produce a minimum sound level of 75 dBA output at 10 feet (3m).
3. The plug-in speaker allows the installer to pre-wire mounting plates and dress the wires before plugging in the speakers.

4. Flush mount applications are achievable without the need for an extension ring.
5. Frequency response shall be a minimum of 400 HZ to 4000 HZ.
6. Rotary switch simplifies field selection of speaker voltage and power settings.

E. Enclosures:
1. The Voice Evacuation/Mass Notification panel shall be housed in a UL-listed cabinet suitable for surface mounting. The cabinet and front shall be corrosion protected and painted red via the powder coat method with manufacturer's standard finish.
2. The back box and door shall be constructed of steel with provisions for electrical conduit connections into the sides and top.
3. The door shall provide a key lock and shall provide for the viewing of all indicators.

F. Power Supply:
1. The main power supply for the Voice Evacuation/Mass Notification panel shall provide up to 7.5 amps of available power for the panel and peripheral devices.
2. Provisions will be made to allow the audio-visual power to be increased as required by adding modular expansion audio-visual power supplies.
3. The power supply shall provide an integral battery charger or may be used with an external battery and charger systems. Battery arrangement may be configured in the field.
4. The main power supply shall continuously monitor all field wires for earth ground conditions.
5. The main power supply shall operate on 120 VAC, 60 Hz or 240 VAC, 50 Hz, and shall provide all necessary power for the Voice Evacuation/Mass Notification panel.

G. BATTERIES:
1. Upon loss of Primary (AC) power to the Voice Evacuation/Mass Notification panel, the batteries shall have sufficient capacity to power the Voice Evacuation/Mass Notification panel for required standby time (24 or 60 hours) followed by 15 minutes of alarm.
2. The batteries are to be completely maintenance free. No liquids are required. Fluid level checks for refilling, spills, and leakage shall not be required.

PART 3 - EXECUTION

3.1 INSTALLATION:

A. Installation shall be in accordance with the NEC, NFPA 72, local and state codes, as shown on the drawings, and as recommended by the major equipment manufacturer.

B. All conduit, junction boxes, conduit supports and hangers shall be concealed in finished areas and may be exposed in unfinished areas. Smoke detectors shall not be installed prior to the system programming and test period. If construction is ongoing during this period, measures shall be taken to protect speakers from contamination and physical damage.

3.2 TEST:

A. The service of a competent, factory-trained engineer or technician authorized by the manufacturer of the fire alarm equipment shall be provided to technically supervise and participate during all of the adjustments and tests for the system. All testing shall be in accordance with NFPA 72.
1. Before energizing the cables and wires, check for correct connections and test for short circuits, ground faults, continuity, and insulation.
2. Open and short notification appliance circuits and verify that trouble signal actuates.
3. Ground all circuits and verify response of trouble signals.
4. Check presence and audibility of tone at all alarm notification devices.
5. When the system is equipped with optional features, the manufacturer's manual shall be consulted to determine the proper testing procedures. This is intended to address such items as verifying voice messages.

3.3 FINAL INSPECTION:

A. At the final inspection a minimum NICET Level II technician shall demonstrate that the system functions properly in every respect.

3.4 INSTRUCTION:

A. Instruction shall be provided as required for operating the system. Hands-on demonstrations of the operation of all system components and the entire system including program changes and functions shall be provided.

B. The contractor or installing dealer shall provide a user manual indicating "Sequence of Operation."

END OF SECTION

SECTION 16745

DATA CABLING

PART 1 – GENERAL

1.1 RELATED DOCUMENTS
A. Drawings and general provisions of the Contract, including General and Supplementary Conditions, Division 00 Information for Bidders, and Division 01 Specification Sections, apply to this Section.

1.2 SECTION INCLUDES
A. Data Cabling.

1.3 RELATED SECTIONS
A. Section 16111 – Conduit.
B. Section 16130 – Boxes.
C. Section 16705 – Conduit Rough-in for Special Systems.

1.4 SYSTEM DESCRIPTION
A. Furnish, install and test all cabling and equipment necessary for a complete data and voice cabling system as specified and indicated on drawings. Conduit, raceway and outlet boxes for the associated outlets shall be provided by this contractor.
B. Insure that the cable run from the distribution frame to the information outlet does not exceed 90 meters (295 Feet).
C. Furnish and install all faceplates, equipment racks, equipment trays and all other items necessary to provide connections at all specified information outlets.
D. The cabling system shall be in compliance to EIA/TIA 568A, TSB-67, and ISO/TEC IS 11801.
E. Support analog and digital voice applications, data system on a common cabling platform. The systems that shall be supported include, but are not limited to
   1. Data Communications – TIA/EIA-568B, Ethernet and Category 6A, UTP plenum cable.
F. The cabling system shall meet specifications for 10/100 Base TX and gigabit network. Provide connections to 10/100 Base-T Hubs by changing patch cords in wiring closets.

1.5 PROJECT/SITE CONDITIONS
A. Examine areas and conditions under which all items are to be installed and notify architect in writing of conditions detrimental to proper completion of the work. Do not proceed with that portion of the work affected until unsatisfactory conditions have been corrected in a manner acceptable to installer.

1.6 SUBMITTALS
A. Submit shop drawings and product data under provisions of Division 01 General Requirements.
B. Contractor shall review all shop drawings prior to submitting them for Architect/Engineer's review. Contractor shall stamp each shop drawing to certify that he has reviewed it. Engineer will not check any shop drawings that Contractor has not stamped with his review certification.

1.7 QUALIFICATIONS
A. Low voltage contractor shall have at least four-(4) years' experience in the installation of similar systems. The low voltage contractor shall provide documentation upon request to certify that all assigned staff have attended training courses corresponding to the type of cabling and equipment specified herein.
B. Low voltage contractor shall currently be licensed to install low voltage electronic cabling systems in the State if applicable.
C. Low voltage contractor shall currently meet all manufacturer's requirements for the provision and installation of all equipment specified herein.
D. Low voltage contractor shall utilize and have operators trained in the utilization of the following test equipment:
   1. Copper Cable test equipment
      a. Fluke 4100
      b. Ideal Lantek 6A or prior approved equal.

2. Printout generated by the test equipment showing jack number and cable footage shall be part of submittals.

1.8 MAINTENANCE SERVICE

A. Provide service and maintenance of cabling system for one (1) year from date of Final Acceptance.
   1. Warranty: Warrant the cabling system against malfunction due to component failure or improper installation for a period of (10) years from the date of Final Acceptance. When notified of a malfunction, proceed to immediately correct the situation by replacement or repair without cost to the Owner. Extend manufacturer's warranties when necessary to achieve the full duration. Clearly indicate provisions of the warranty in the Warranty Manual.
   2. Response Time: Within the Warranty period, low voltage contractor will replace defective parts within one business day after receiving notification of a problem.
   3. Warranty inspection: Prior to expiration of the one-year warranty period, arrange to make an inspection of the cabling system. Make adjustments and correct defects that exist to bring the system up to as-new specifications.

PART 2 – PRODUCTS

2.1 GENERAL

A. Low voltage contractor shall provide written notification to Engineer, prior to bidding, of any discrepancies in model or part numbers specified.
B. Low voltage contractor shall provide written notification to Engineer, prior to bidding, of the announced discontinuation or replacement of any items specified herein.
C. Low voltage contractor shall provide all necessary components, mounting hardware and accessories required to install the materials specified herein.

2.2 PRODUCT SUBSTITUTIONS

A. No substitutions will be allowed.

2.3 MATERIALS

A. Cabling:
   1. Data Cable: Furnish and install category 6A plenum 4-pair 24awg, solid copper unshielded twisted-pair (UTP) cable or quality that exceeds EIA/TIA-568B.
      a. Approved Manufacturers: Mohawk, CommScope, Belden, Siemon.
   2. Fiber Optic Intra-Building Backbone (Multimode) Cable: 18-Strand 62.5-micron multimode, “FDDI” or higher grade, tight buffered (900 micron). Plenum rated distribution cable with armored jacket, orange.
      a. Acceptable Manufacturers: Mohawk, CommScope, Seicor, Beltec.
B. Faceplates:
   1. Data Drop Locations:
      a. Six gang junction box, single gang faceplate.
      b. Acceptable Manufacturers: Hubbell, Lucent, Panduit, Siemon
      c. Cat-6A Data Jack: Cat-6A, high density, T568B wired, orange color “RJ45” jack.
      d. Refer to Drawings for quantity of jacks.
      e. Provide a minimum of (2) data drops at each location, whether specifically indicated or not.
C. Patch Panel
   1. Unshielded Twisted Pair (UTP) Patch Panel and Associated Items:
      a. 48-Port Patch Panels: rack mounted, 48-port cat-6A patch panel, with cable support bar and color-coded label strip, T568B wired in MDF room 57.
         1) Acceptable Manufacturer: Siemon HD5-48, Panduit or equal.

2) Contractor to provide 48-port patch panels, in quantities as required to accommodate all new data drops. Contractor to allow for ten percent (10%) overage of actual number of required ports.

D. Patch Panels:
   1. Fiber Optic IDF Cabinets and Associated Items:
      a. Fiber Optic Adapter Panels: “LC” adapter panel with eighteen duplex LC multi/single-mode adapters.
         1) Acceptable Manufacturers: Hubbell, Panduit, Siemon
      b. Blank Adapter Panels: Filler panel with no adapters.
         1) Acceptable Manufacturers: Hubbell, Panduit, Siemon

PART 3 – EXECUTION

3.1 GENERAL

A. Install all equipment and components in accordance with manufacturer's written instructions, in compliance with NEC, and with recognized industry practices, to ensure that all items comply with specifications and serve intended purposes.
B. All Cabling and equipment shall be installed in accordance with good engineering practices as established by the EIA and the NEC. Cabling shall meet all applicable local, State, and Federal building codes.
C. Record serial numbers of all items provided that are serialized. To be completed prior to Final Acceptance.
D. All items must be complete as specified prior to Final Acceptance. Ensure cabling meets all specifications and standards defined herein.

3.2 INSTALLATION

A. Cabling - General:
   1. **All cables shall be provided in conduits except cables above accessible ceiling space or within exposed ceiling cavities. Cables within these areas shall be run in cable tray.**
   2. All cables shall be plenum rated.
   3. Furnish and install cabling runs between IT room and all outlets specified on drawings. A dedicated cabling run shall be utilized for each Faceplate Jack.
   4. Conduit, Raceways and Outlet Boxes, to be provided as required.
   5. Furnish and install Faceplates and Faceplate Jacks in Outlet Boxes for all outlets specified on drawings.
   6. All Jacks shall be terminated in accordance with Cable Pinout Detail.
   7. Furnish and install grommets in conduit to prevent damage to insulation or conductors.
   8. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer’s published torque-tightening values for equipment connectors.
   9. Do not damage cabling and shielding. Avoid excessive and sharp bends. Ensure manufacturer's recommended pulling tensions are not exceeded.
   10. Allow sufficient slack in cable to prevent premature deterioration of cable system components and to assist in the maintenance and servicing of cable and/or other building systems and components.
   11. Fittings or connections are allowed only at the input and output of devices. Splicing shall not be accepted in any cable runs. The entire cable run shall be replaced in all such instances.
   12. All cable must be free of tension at both ends as well as over the length of the run. In cases where a cable must bear some stress, Kellum grips may be used to spread the strain over a longer length of the cable. Cables that require service loops or additional length should be coiled from 100-200% of their recommended minimum bend radius. The coil shall then be cabled tied and attached to a nearby support.
   13. Excess cable behind faceplate connections shall be pulled back into ceiling spaces and secured in such a manner as to prevent damage to cabling or connections.

14. Use a cable tie tool to install cable ties with appropriate pressure to the cable bundles so not to damage cable and provide a smooth cut of excess cable tie. Cable ties MUST be able to be turned freely around the bundle of cable. Cable bundles shall be limited to 2” diameter. Cable ties to be used for cable bundle “above the ceiling”.
15. Use Velcro® Bands to secure cable bundles from where the cable exits the ceiling and terminates at the equipment room.

B. Grounding: Ground all equipment per manufacturers' instructions and NEC guidelines.
C. Labeling:
   1. Brother P-Touch, Casio EZ Label, Brady or prior approved equal self-adhesive labels shall be utilized for all Outlet and Patch Panel labeling. A sample of EACH information outlet with 1' Minimum of each cable terminated shall be required for approval.
   2. Place labels on Faceplates and inside Outlet Boxes for all Outlet locations.
   3. Label all patch panel terminations with the identical numbers used at outlet locations.
   4. Label the ends of all cabling runs with Panduit Pan-Ty, Brady or equal labels in permanent marker.

3.3 CERTIFICATION AND DOCUMENTATION

A. All circuits must be certified to comply with EIA/TIA 568B and TSB40 specifications for 250 MHZ [100 megabits per second (MBPS)] data systems including NExT (near end cross talk), TD (time domain reflectometer) distance and attenuation for all pairs and must meet or exceed all NEC, NFPA, BOCA and local building codes pertaining to low voltage signal cabling.
B. In order to verify certification and provide reference for future use, the contractor shall provide a complete documented cable performance testing certification on each UTP cable segment per ANSI/EIA/TIA 568B, TSB40 on all pairs swept at all frequencies. Documentation must be provided in a magnetic media format agreed to in writing by the Owner with results including the following for all pairs at 100 MHZ, 150 MHZ and 250MHz:
   1. Cross talk levels (NExT).
   2. Attenuation.
   3. TDR (cable length).
   4. Signal to noise ratio (SNR).
   5. Testing for Shorts/Breaks, Correct Pairing
C. Testing must be done in both directions: Permanent Link
   1. From the station outlet/connector.
   2. From the equipment room.
D. Results must meet or exceed all parameters for proposed Category 6 structured premise cabling systems. Provide hard copy test results for each cabling run in Technical Manual.
E. Low voltage contractor shall utilize and have operators trained in the utilization of the following test equipment:
   1. Copper Cable test equipment
      a. Ideal Lantek 6A or prior approved equal.
   2. Printout generated by the test equipment showing jack number and cable footage shall be part of submittals see Section 1.06

END OF SECTION

SECTION 16801

GYMNASIUM SOUND REINFORCEMENT SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The General Conditions, Supplementary Conditions, and General Requirements apply to the Work specified in this Section.
B. Section 16010, “Basic Electrical Requirements,” applies to the Work specified in this section.

1.2 DESCRIPTION

A. Work included:
   1. Furnish all equipment and labor necessary for a reasonably incidental to the complete installation of the Local Sound System as outlined in the following Specifications.
   2. System wiring shall be installed in conduit. Systems shall be complete including all equipment, wiring, conduit, outlet and junction boxes, and all accessories, whether specifically mentioned or not, required for the systems specified herein and as shown on the Drawings.

1.3 QUALITY ASSURANCE

A. Acceptable equipment manufacturers for the sound systems shall be as noted within these specifications. Contractor shall include the bid of ITR Systems, Downers Grove, IL (630) 512-0044, the approved audio system integrator for this project.
B. Systems shall be installed by a sound contracting firm with factory-trained and approved technicians who shall make adjustments, check operation, and approve entire system and shall instruct User’s personnel in the use and operation of all sound equipment furnished.
C. Contractor shall provide a complete set of operating instructions, including circuit diagrams and other information necessary for proper installation, operation, and service maintenance.

1.4 SUBMITTALS

A. Shop drawings for the system shall be submitted for approval prior to fabrication and installation.
B. Shop drawings shall include the following data:
   1. Catalog Data: Manufacturer’s literature and illustration.
   2. Dimensions and Performance Data of Equipment.
   3. Functional Block Diagrams.

PART 2 - PRODUCTS

2.1 EQUIPMENT

A. The sound system will provide for the amplified distribution of program material to the outlined speaker system. Program origination will be from system sources and/or other sources outlined in the following specifications.
B. The equipment outlined reflects a definite performance standard acceptable. Equipment submitted as equal to that specified is subject to approval no less than (10) days prior to the original bid date of the project. Upgrading or additions will be the financial responsibility of the electrical contractor.
C. The equipment to be provided and installed by factory-trained technicians.

2.2 CONTROL EQUIPMENT

A. LOCAL SOUND SYSTEM
   1. Equipment Cabinet: Lowell LWR-1623 Wall Cabinet with LFD-16FV Key Locking Front Door or Atlas equivalent
   2. Storage Drawer: Lowell UD3 Storage Drawer
   3. Sequencing Surge Protector: APC G5BLK Rack-Mounted Sequencing Surge Protector
   4. Mixer/Processor: Allen & Heath AHM16 8-Channel Mixer/Processor
   5. Touchscreen Controller: Allen & Heath CC-7 7” Touchscreen Controller
   6. Amplifier: Ashly CA-1.52 Power Amplifier

7. Control Modules: Provide the appropriate quantity and type module for each system input and include override electronics for central school intercom system priority.
8. 8. Cabinet Hardware Provide matching filler panels for all unused spaces as well as labels for each control and any hardware connectors, etc., for a complete and operating system.

2.3 PROGRAM SOURCES

A. Media Player Denon DN-300Z Media Player with Bluetooth, SD, USB, 3.5mm

2.4 SPEAKER SYSTEM

A. Community Loudspeakers 6 - Community V2-1596W 2-way 15” speakers in White
B. Mounting Brackets 6- VB-Y15W Mounting Brackets in White

2.5 WIRELESS MICROPHONE SYSTEM

A. Dual Channel Receiver MiPro ACT-727 Dual Channel receiver
B. Handheld Transmitter Mics MiPro ACT-700H Handheld Mics
C. Bodypack Transmitter MiPro ACT-700T Bodypack
D. Headworn Mic MiPro MU-55HNX Waterproof headworn mic

2.6 SYSTEMS CABLE

A. Speaker Cable West Penn 227 or equivalent 12ga x 2C
B. Microphone Cable West Penn 291, Belden 1503A, or equivalent

2.7 ACCESSORIES

A. Provide the following system accessories to be used with the Gymnasium Sound System
   1. Microphone Stands Provide (2) Atlas MS12C Floor Stand and (1) Shure S37A Desk Stand
   2. Microphone Jack Provide (1) Switchcraft K3F or Conquest CP2-DF dual XLR Microphone Jack on 1-gang Stainless Steel plate.

PART 3 - EXECUTION

3.1 EXECUTION

A. Install all wiring in conduits in strict conformity with standard broadcast practice.
B. Insulate all microphone and 600 Ohm lines from each other and from conduit. Verify that conduits have been mechanically and electrically connected to boxes and grounded. Do not splice lines in conduit.
C. Do not ground microphone line shields, except at microphone frame and at console input connectors.
D. Ground other shields of two (2) conductor cables only at one (1) end, as appropriate. Terminate “floating” ends with wedge-on collars, plastic tape, or heat-shrinkable tubing.
E. Maintain continuity of shields at all connecting points.
F. Connect all audio grounds in an equipment rack to a common point.
G. Install required receptacles and cover plates in outlet boxes provided and installed by electrical contractor.
H. Install all equipment neatly, plumb, square, and true to line and level.
I. Clearly, logically, and permanently label all controls, jacks, receptacles, and cable terminations; tag cable ends with labels corresponding with wiring diagrams. Also label rack-mounted equipment items, when more than one (1) of the same item is used, to identify the circuit into which each item is wired.
J. The Installing Contractor will have been in business a minimum of five (5) years and have a minimum of five (5) similar successful installations currently in usage.
K. The Contractor shall provide a pre-scheduled demonstration and instruction session upon completion of installation. Provide a sign-in sheet for recording all attendees present and turn-in this sheet along with closeout documentation.

END OF SECTION

SECTION 16802

COMMONS SOUND REINFORCEMENT SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. The General Conditions, Supplementary Conditions, and General Requirements apply to the Work specified in this Section.
B. Section 16010, “Basic Electrical Requirements,” applies to the Work specified in this section.

1.2 DESCRIPTION

A. Work included:
   1. Furnish all equipment and labor necessary for a reasonably incidental to the complete installation of the Local Sound System as outlined in the following Specifications.
   2. System wiring shall be installed in conduit. Systems shall be complete including all equipment, wiring, conduit, outlet and junction boxes, and all accessories, whether specifically mentioned or not, required for the systems specified herein and as shown on the Drawings.

1.3 QUALITY ASSURANCE

A. Acceptable equipment manufacturers for the sound systems shall be as noted within these specifications. Contractor shall include the bid of ITR Systems, Downers Grove, IL (630) 512-0044, the approved audio system integrator for this project.
B. Systems shall be installed by a sound contracting firm with factory-trained and approved technicians who shall make adjustments, check operation, and approve entire system and shall instruct User’s personnel in the use and operation of all sound equipment furnished.
C. Contractor shall provide a complete set of operating instructions, including circuit diagrams and other information necessary for proper installation, operation, and service maintenance.

1.4 SUBMITTALS

A. Shop drawings for the system shall be submitted for approval prior to fabrication and installation.
B. Shop drawings shall include the following data:
   1. Catalog Data: Manufacturer’s literature and illustration.
   2. Dimensions and Performance Data of Equipment.
   3. Functional Block Diagrams.

PART 2 - PRODUCTS

2.1 EQUIPMENT

A. The sound system will provide for the amplified distribution of program material to the outlined speaker system. Program origination will be from system sources and/or other sources outlined in the following specifications.
B. The equipment outlined reflects a definite performance standard acceptable. Equipment submitted as equal to that specified is subject to approval no less than (10) days prior to the original bid date of the project. Upgrading or additions will be the financial responsibility of the electrical contractor.
C. The equipment to be provided and installed by factory-trained technicians.

2.2 CONTROL EQUIPMENT –

A. LOCAL SOUND SYSTEM
   1. Equipment Cabinet Lowell LWR-1623 Wall Cabinet with LFD-16FV Key-Locking Front Door or Atlas equivalent
   2. Storage Drawer Lowell UD3 Storage Drawer
   3. Sequencing Surge Protector APC G5BLK Rack-Mounted Sequencing Surge Protector
   4. Mixer/Processor Allen & Heath AHM16 8-Channel Mixer/Processor

5. Touchscreen Controller Allen & Heath CC-7 7” Touchscreen Controller
6. Amplifier: Grommes AX500 Power Amplifier
7. Control Modules: Provide the appropriate quantity and type module for each system input and include override electronics for central school intercom system priority.
8. Cabinet HardwareProvide matching filler panels for all unused spaces as well as labels for each control and any hardware connectors, etc., for a complete and operating system.

2.3 PROGRAM SOURCES

A. Media Player Denon DN-300Z Media Player with Bluetooth, SD, USB, 3.5mm

2.4 SPEAKER SYSTEM

A. Community Loudspeakers 8 - Community DP8-W 2-way 8” pendant speakers in White

2.5 WIRELESS MICROPHONE SYSTEM

A. Dual Channel Receiver MiPro ACT-727 Dual Channel receiver
B. Handheld Transmitter Mics MiPro ACT-700H Handheld Mics
C. Bodypack Transmitter MiPro ACT-700T Bodypack
D. Headworn MicMiPro MU-55HNX Waterproof headworn mic

2.6 SYSTEMS CABLE

A. Speaker Cable West Penn 226 or equivalent 14ga X 2
B. Microphone Cable West Penn 291, Belden 1503A, or equivalent

2.7 ACCESSORIES

A. Provide the following system accessories to be used with the Commons Sound System
   1. Microphone Stands Provide (2) Atlas MS12C Floor Stand and (1) Shure S37A Desk Stand
   2. Microphone Jack Provide (1) Switchcraft K3F or Conquest CP2-DF dual XLR Microphone Jack on 1-gang Stainless Steel plate.

PART 3 - EXECUTION

3.1 EXECUTION

A. Install all wiring in conduits in strict conformity with standard broadcast practice.
B. Insulate all microphone and 600 Ohm lines from each other and from conduit. Verify that conduits have been mechanically and electrically connected to boxes and grounded. Do not splice lines in conduit.
C. Do not ground microphone line shields, except at microphone frame and at console input connectors.
D. Ground other shields of two (2) conductor cables only at one (1) end, as appropriate. Terminate “floating” ends with wedge-on collars, plastic tape, or heat-shrinkable tubing.
E. Maintain continuity of shields at all connecting points.
F. Connect all audio grounds in an equipment rack to a common point.
G. Install required receptacles and cover plates in outlet boxes provided and installed by electrical contractor.
H. Install all equipment neatly, plumb, square, and true to line and level.
I. Clearly, logically, and permanently label all controls, jacks, receptacles, and cable terminations; tag cable ends with labels corresponding with wiring diagrams. Also label rack-mounted equipment items, when more than one (1) of the same item is used, to identify the circuit into which each item is wired.
J. The Installing Contractor will have been in business a minimum of five (5) years and have a minimum of five (5) similar successful installations currently in usage.

K. The Contractor shall provide a pre-scheduled demonstration and instruction session upon completion of installation. Provide a sign-in sheet for recording all attendees present and turn-in this sheet along with closeout documentation.

END OF SECTION

SECTION 17100

DIRECTE DIGITAL CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General Conditions and Division 1, 15 and 16 Specification Sections, apply to this Section.

1.2 SECTION INCLUDES

A. Control equipment.
B. Software.
C. Instrument and control elements.

1.3 RELATED SECTIONS

A. Section 17600 - Sequence of Operation for HVAC controls.

1.4 REFERENCES

A. ASME MC85.1 - Terminology for Automatic Control.
B. NEMA EMC1 - Energy Management Systems Definitions.
C. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
D. NFPA 70 - National Electrical Code.
E. NFPA 90A - Installation of Air Conditioning and Ventilation Systems.

1.5 SYSTEM DESCRIPTION

A. Provide hardware and software as required to fully integrate and support extension to existing District Building Automation System. New graphics shall match in quality and type used throughout the district. Floor plan graphics are required too.
   1. All remote buildings and server shall have their JACE and/or workbench software updated (Owner will pay for all license upgrades that are needed):
      a. Grissom Middle School
      b. Bannes Elementary School
      c. Bannes Bus Lot Shed
      d. Keller Elementary School
      e. Duvan Warehouse
      f. Prairie View Middle School (2 Total)
      g. Millennium Elementary School
      h. District Server and District Laptop.
   2. Provide back-up disc(s) to owner of all software installed on all ‘Supervisory’ and ‘DDC System’ controllers within the building.
   3. JACE Software update to be pre-formed after September 1, 2025 for ALL buildings.

B. All control points listed in Section 17600 "Sequence of Operation for HVAC controls" shall be performed by the DDC system and displayed on the Operator Workstation. Any other control work required to complete the sequence of operation specified in Section 17600 may be electric or electronic. Contractor shall provide all transformers, sensors, switches, relays etc. necessary for a complete operating system.

C. Provide automatic temperature control field monitoring and control system using BACnet field programmable microprocessor-based units with communications to the existing Building Automation System.
   1. FX-80 JACE controller to be provided with a minimum of two (2) RS485 ports, 150 devices (7,500 points) and 5-year software maintenance. Increase device/point count and RS485 port cards as required by actual building/system requirements.
   2. Install new FX-80 in Boiler Room 115.

D. Provide base system on distributed system of fully intelligent, stand-alone controllers, operating in a multi-tasking, multi-user environment on token passing network, with central and remote hardware, software, and interconnecting wire and conduit.

E. Include computer software and hardware, operator input/output devices, control units, local area networks (LAN), sensors, control devices, actuators.

F. Provide control systems consisting of temperature sensors, thermostats, control valves, dampers, indicating devices, interface equipment and other apparatus and accessories required to operate mechanical systems, and to perform functions specified.
G. Furnish and install all power wiring and conduit necessary for the BAS control system for a complete operating system. Install per Division 16.
H. Include installation and calibration, supervision, adjustments, and fine tuning necessary for complete and fully operational system.

1.6 SUBMITTALS FOR REVIEW

A. See Division 1 Requirements.
B. Product Data: Provide data for each system component and software module.
C. Shop Drawings:
   1. List connected data points, including connected control unit and input device.
   2. Indicate system graphics indicating monitored systems, data (connected and calculated) point addresses, and operator notations. Provide demonstration diskette containing graphics.
   3. Show system configuration with peripheral devices, batteries, power supplies, diagrams, modems, and interconnections.
   4. Indicate description and sequence of operation of operating, user, and application software.
   5. Ensure terminology used in submittals conforms to ASME MC85.1.

1.7 SUBMITTALS FOR INFORMATION

A. See Division 1 Requirements.
B. Manufacturer's Instructions: Indicate manufacturer's installation instructions for all manufactured components.

1.8 SUBMITTALS AT PROJECT CLOSEOUT

A. See Division 1 Requirements.
B. Project Record Documents: Record actual locations of control components, including control units, thermostats, and sensors.
   1. Revise shop drawings to reflect actual installation and operating sequences.
   2. Include data specified in "Submittals" in final "Record Documents" form.
C. Operation and Maintenance Data:
   1. Include interconnection wiring diagrams complete field installed systems with identified and numbered, system components and devices.
   2. Include keyboard illustrations and step-by-step procedures indexed for each operator function.
   3. Include inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.
D. Warranty: Submit manufacturer’s warranty and ensure forms have been filled out in Owners name and registered with manufacturer.

1.9 APPROVED INSTALLING CONTRACTORS, QUALITY ASSURANCE

A. General
   1. The Building Automation System Contractor shall be a manufacturer-approved franchised dealer that is regularly engaged in the engineering, programming, installation and service of total integrated building management systems.
   2. The BAS Manufacturer shall be a recognized national manufacturer of BAS.
   3. The BAS Contractor shall have a fully staffed branch facility within a 100-mile radius of the job site supplying complete maintenance and support services on a 24-hour, 7-day-a-week basis.
   4. As evidence and assurance of the contractor’s ability to support the Owner's system with service and parts, the contractor must have been in the BAS business for at least the last fifteen (15) years and show proof of this.

5. The Building Automation System architecture shall consist of the products of a manufacturer regularly engaged in the production of Building Automation Systems and shall be the manufacturer's latest standard of design at the time of bid.

B. Workplace Safety and Hazardous Materials
   1. Provide a safety program in compliance with the Contract Documents.
   2. The BAS Contractor shall have a corporately certified comprehensive Safety Certification Manual and a designated Safety Supervisor for the Project.
   3. The Contractor and its employees and sub-trades comply with federal, state and local safety regulations.
   4. The Contractor shall ensure that all subcontractors and employees have written safety programs in place that covers their scope of work and that their employees receive the training required by the OSHA having jurisdiction for at least each topic listed in the Safety Certification Manual.
   5. Hazards created by the Contractor or its subcontractors shall be eliminated before any further work proceeds.
   6. Hazards observed but not created by the Contractor or its subcontractors shall be reported to either the General Contractor or the Owner within the same day. The Contractor shall be required to avoid the hazard area until the hazard has been eliminated.
   7. The Contractor shall sign and date a safety certification form prior to any work being performed, stating that the Contractors' company is in full compliance with the Project safety requirements.
   8. The Contractor's safety program shall include written policy and arrangements for the handling, storage and management of all hazardous materials to be used in the work in compliance with the requirements of the authority having jurisdiction at the Project site.
   9. The Contractor's employees and subcontractor's staff shall have received training as applicable in the use of hazardous materials and shall govern their actions accordingly.

C. Quality Management Program
   1. Designate a competent and experienced employee to provide BAS Project Management. The designated Project Manager shall be empowered to make technical, scheduling and related decisions on behalf of the BAS Contractor. At minimum, the Project Manager shall:
      a. Manage the scheduling of the work to ensure that adequate materials, labor and other resources are available as needed.
      b. Manage the financial aspects of the BAS contract.
      c. Coordinate as necessary with other trades.
      d. Be responsible for the work and actions of the BAS workforce on site.

D. Approved Installing Contractor
   1. Building Automation Solutions (855) 597-3339
   2. Applied Controls, Inc (630) 836-9440.
   3. Integrated Control Technologies (630) 520-6000.

E. Acceptable Systems
   1. Facility Explorer by Johnson Controls
   2. No substitutions.

1.10 REGULATORY REQUIREMENTS

A. Conform to the 2012 Health/Life Safety Code for Public Schools, 23 Illinois Administrative Code 180.
B. Conform to the 2015 International Building Code (IBC).
C. Conform to the 2015 International Existing Building Code (IEBC).
D. Conform to the 2015 International Fuel Gas Code (IFGC).
E. Conform to the 2015 International Property Maintenance Code (IPMC).
F. Conform to the 2015 International Fire Code (IFC), excluding Chapter 4.
G. Conform to the 2015 International Energy Conservation Code (IECC).
H. Conform to the 1997 Illinois Accessibility Code, 71 Illinois Administrative Code 400.
I. Conform to 2014 State of Illinois Plumbing Code, 77 Illinois Administrative Code 890.

J. Conform to the 2010 Illinois State Fire Marshall Boiler and Pressure Vessel Safety Act, 41 Illinois Administrative Code 120.
K. Conform to the 2015 International Mechanical Code (IMC).
L. Conform to the 2009 ICC Electrical Code.
M. Conform to 2008 NFPA 70, National Electrical Code.
N. Conform to 2007 NFPA 72, National Fire Alarm Code.
O. Products: Listed and classified by Underwriter's Laboratories, Inc. as suitable for the purpose specified and indicated.

PART 2 - PRODUCTS

2.1 SUPERVISORY CONTROLLER

A. Approved Manufacturer: Johnson Controls Inc. (JCI) LP-FX80 Tridium JACE (No substitutions or deviations from the above will be permitted). The FX- 80 Supervisory Controller must provide the following hardware features as a minimum:
   1. Communications
      a. One 10/100 Mb Ethernet Port – RJ-45 connection
      b. One RS-232 port
      c. One RS-485 port (up to 57,600 baud)
      d. Expandable communications ports including LON, RS485, Modem, Wireless Terminal Equipment Control
      e. All required protocol drivers are included.
   2. Optional Inputs/Outputs
      a. Four form A SPST relay outputs rated for 24 VAC/VDC @ 500 MA resistive each with individual LED indicators
      b. Eight Universal Inputs for 10K NTC, 4-20 MA, 0-10 V, Dry contact
      c. Four 0-10v analog outputs.
   3. Optional Inputs/Outputs
      a. Ten form A SPST relay outputs rated for 24 VAC/VDC @ 500 MA resistive each with individual LED indicators
      b. Sixteen Universal Inputs for 10K NTC, 4-20 MA, 0-10 V, Dry contact
      c. Eight 0-10 V analog outputs.
   4. Optional Remote Inputs/Outputs
      a. Four form A SPST relay outputs rated for 24 VAC/VDC @ 500 MA resistive each with individual LED indicators
      b. Eight Universal Inputs for 10K NTC, 4-20 MA, 0-10 V, Dry contact
      c. Four 0-10v analog outputs.
      d. Communicates to Supervisory Controller via standard RS-485 connection.
   5. Battery Backup
      a. Battery backup provided for all on board functions including I/O
      b. Battery is monitored and trickle charged
      c. Battery maintains processor operation through power failures for a pre-determined interval, and then writes all data to flash memory, shuts the processor down, and maintains the clock for three months.
   6. Environment
      a. Must be capable of operation over a temperature range of
      b. 32 ºF to 122 ºF.
      c. Must be capable of withstanding storage temperatures of between
      d. 32 ºF to 140 ºF.
      e. Must be capable of operation over a humidity range of 5% to 95% RH, non-condensing
   7. The Supervisory Controller shall be a fully user-programmable device capable of providing all of the capability described herein.
   8. Automation network – The Supervisory Controller shall reside on the automation network. Each Supervisory Controller shall support one or more sub-networks of controllers.

9. The Supervisory Controller shall have the capability to communicate directly with Modbus without the use of an additional gateway.
10. The Supervisory Controller shall have the capability to provide secure communications via SSL (Secure Socket Layer).
11. User Interface – Each Supervisory Controller shall have the ability to deliver a web-based user interface as previously described. All computers connected physically or virtually to the automation network shall have access to the web-based UI.
12. Power Failure – In the event of the loss of normal power, The Supervisory Controller shall continue to operate for a defined period after which there shall be an orderly shutdown of all programs to prevent the loss of database or operating system software. Flash memory shall be incorporated for all critical controller configuration data.
    a. During a loss of normal power, the control sequences shall go to the normal system shutdown conditions.
    b. Upon restoration of normal power and after a minimum off-time delay, the controller shall automatically resume full operation without manual intervention through a normal soft-start sequence.
13. Certification – All controllers shall be listed by Underwriters Laboratories (UL).

2.2 DDC SYSTEM CONTROLLERS

A. Approved Manufacturer: General Purpose Fully Programmable Controllers shall be JCI BACnet FX-PCA/FX-PCG/FX-PCV. (No substitutions or deviations from the above will be permitted). -
   1. The General-Purpose Programmable Controller (PCA/PCG) by JCI shall be a fully user-programmable, digital controller that communicates via BACnet MS/TP protocol. There shall be no substitutions made as the owner has standardized on these.
      a. The PCG shall support BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9 on the controller network.
         1) A BACnet Protocol Implementation Conformance Statement shall be provided for the PCG.
         2) The Conformance Statement shall be submitted 10 days prior to bidding.
   2. The PCG shall employ a finite state control engine to eliminate unnecessary conflicts between control functions at crossover points in their operational sequences. Suppliers using non-state based DDC shall provide separate control strategy diagrams for all controlled functions in their submittals.
   3. The PCG shall be factory programmed with a continuous adaptive tuning algorithm that senses changes in the physical environment and continually adjusts loop tuning parameters appropriately. Controllers that require manual tuning of loops or perform automatic tuning on command only shall not be acceptable.
   4. The PCG shall be assembled in a plenum-rated plastic housing with flammability rated to UL94-5VB.
   5. The PCG shall include a removable base to allow pre-wiring without the controller.
   6. The PCG shall include troubleshooting LED indicators to identify the following conditions:
      a. Power On
      b. Power Off
      c. Download or Startup in progress, not ready for normal operation
      d. No Faults
      e. Device Fault
      f. Field Controller Bus - Normal Data Transmission
      g. Field Controller Bus - No Data Transmission
      h. Field Controller Bus - No Communication
      i. Sensor-Actuator Bus - Normal Data Transmission
      j. Sensor-Actuator Bus - No Data Transmission
      k. Sensor-Actuator Bus - No Communication
   7. The PCG shall accommodate the direct wiring of analog and binary I/O field points.

8. The PCG shall support the following types of inputs and outputs:
   a. Universal Inputs - shall be configured to monitor any of the following:
      1) Analog Input, Voltage Mode
      2) Analog Input, Current Mode
      3) Analog Input, Resistive Mode
      4) Binary Input, Dry Contact Maintained Mode
   b. Binary Inputs - shall be configured to monitor either of the following:
      1) Dry Contact Maintained Mode
      2) Pulse Counter Mode
   c. Analog Outputs - shall be configured to output either of the following
      1) Analog Output, Voltage Mode
      2) Analog Output, current Mode
   d. Binary Outputs - shall output the following:
      1) 24 VAC Triac
   e. Configurable Outputs - shall be capable of the following:
      1) Analog Output, Voltage Mode
      2) Binary Output Mode
9. The PCG shall have the ability to reside on a Field Controller Bus (FC Bus).
   a. The FC Bus shall be a Master-Slave/Token-Passing (MS/TP) Bus supporting BACnet Standard protocol SSPC-135, Clause 9.
   b. The FC Bus shall support communications between the PCGs and the Supervisory Controller.
   c. The FC Bus shall also support Expansion I/O (PCX) communications with the PCG and with the Supervisory Controller.
   d. The FC Bus shall operate at a maximum distance of 15,000 Ft. between the PCG and the furthest connected device.
10. The PCG shall have the ability to monitor and control a network of sensors and actuators over a Sensor-Actuator Bus (SA Bus).
    a. The SA Bus shall be a Master-Slave/Token-Passing (MS/TP) Bus supporting BACnet Standard Protocol SSPC-135, Clause 9.
    b. The SA Bus shall support up to 10 devices per trunk.
    c. The SA Bus shall operate at a maximum distance of 1,200 Ft. between the PCG and the furthest connected device.
11. The PCG shall have the capability to execute complex control sequences involving direct wired I/O points as well as input and output devices communicating over the FC Bus or the SA Bus.
12. The PCG shall support, but not be limited to, the following:
    a. Chilled water/central plant automation applications including but not limited to:
       1) The selection and sequencing of up to 8 chillers of different sizes.
       2) The selection and sequencing of up to 8 (each) primary and secondary chilled water pumps of varying pump capacities.
       3) The selection and sequencing of up to 8 condenser water pumps.
       4) The selection and sequencing of cooling towers and bypass valve, including single speed, multi-speed, and Vernier control.
       5) A proven and documented central cooling plant optimization program that incorporates custom equipment efficiency profiles, without rewriting software code, in order to meet the building load using the least amount of energy as calculated.
       6) The use of advanced control algorithms that apply equipment specific parameters, including operational limits and efficiency profiles, in order to determine equipment-start and runtime preferences.
       7) The identification of the most efficient equipment combination and automatic control of state and speed of all necessary equipment to balance runtime, optimize timing and sequencing and ensure the efficiency and stability of the central cooling plant.

8) The control definition for the chiller plant in a single FX-PCG, as supported by available memory and point Input / Output (I/O), or capable of being split across multiple FX-PCGs.

b. Heating central plant applications.
c. Built-up air handling units for special applications.
d. Terminal and packaged units and unit ventilators.
e. Special programs as required for systems control.

13. The PCG shall support a Local Controller Display (DIS) either as an integral part of the PCG or as a remote device communicating over the SA Bus. Local displays shall be provided when controllers are used in central plant or AHU applications but are not required on simple systems such as unit ventilators.
    a. The Display shall use a BACnet Standard SSPC-135, clause 9 Master-Slave/Token-Passing protocol.
    b. The Display shall allow the user to view monitored points without logging into the system.
    c. The Display shall allow the user to view and change set points, modes of operation, and parameters.
    d. The Display shall provide password protection with user adjustable password timeout.
    e. The Display shall be menu driven with separate paths for:
        1) Input / Output
        2) Parameter / Set point
        3) Overrides
    f. The Display shall use easy-to-read English text messages.
    g. The Display shall allow the user to select the points to be shown and in what order.
    h. The Display shall support a back lit Liquid Crystal Display (LCD) with adjustable contrast and brightens and automatic backlight brightening during user interaction.
    i. The display shall be a minimum of 4 lines and a minimum of 20 characters per line
    j. The Display shall have a keypad with no more than 6 keys.
    k. The Display shall be panel mountable.

B. Approved Manufacturer: Programmable Controller Expansion I/O Modules shall be JCI FX-PCX (No substitutions or deviations from the above will be permitted). Programmable Controller Expansion I/O Modules (PCX)
    1. The Programmable Controller Expansion I/O Module (PCX) provides additional inputs and outputs for use in the PCG.
    2. The PCX shall communicate with the PCG over the FC Bus or the SA Bus.
    3. The PCX shall support BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9 on the controller network.
        a. A BACnet Protocol Implementation Conformance Statement shall be provided for the PCG.
        b. The Conformance Statement shall be submitted 10 days prior to bidding.
    4. The PCX shall be assembled in a plenum-rated plastic housing with flammability rated to UL94-5VB.
    5. The PCX shall have a minimum of 4 points to a maximum of 17 points.
    6. The PCX shall support the following types of inputs and outputs:
        a. Universal Inputs - shall be configured to monitor any of the following:
            1) Analog Input, Voltage Mode
            2) Analog Input, Current Mode
            3) Analog Input, Resistive Mode
            4) Binary Input, Dry Contact Maintained Mode
        b. Binary Inputs - shall be configured to monitor either of the following:
            1) Dry Contact Maintained Mode
            2) Pulse Counter Mode
        c. Analog Outputs - shall be configured to output either of the following:
            1) Analog Output, Voltage Mode
            2) Analog Output, current Mode

d. Binary Outputs - shall output the following:
   1) 24 VAC Triac
e. Configurable Outputs - shall be capable of the following:
   1) Analog Output, Voltage Mode
   2) Binary Output Mode

7. The PCX shall include troubleshooting LED indicators to identify the following conditions:
   a. Power On
   b. Power Off
   c. Download or Startup in progress, not ready for normal operation
   d. No Faults
   e. Device Fault
   f. Normal Data Transmission
   g. No Data Transmission
   h. No Communication

C. Programmable VAV Box Controller shall be JCI-FX-PCV (No Substitutions Permitted).
1. The Programmable VAV Box Controller (PCV) shall provide both standalone and networked direct digital control of pressure-independent, variable air volume terminal units. It shall control both single and dual duct applications.
2. The PCV shall support BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9 on the controller network.
   a. A BACnet Protocol Implementation Conformance Statement shall be provided for the PCV.
   b. The Conformance Statement shall be submitted 10 days prior to bidding.
3. The PCV shall have internal electrical isolation for AC power, DC inputs, and MS/TP communications. An externally mounted isolation transformer shall not be acceptable.
4. The PCV shall be a configurable digital controller with integral differential pressure transducer and damper actuator. All components shall be connected and mounted as a single assembly that can be removed as one piece.
5. The PCV shall be assembled in a plenum-rated plastic housing with flammability rated to UL94-5VB.
6. The integral damper actuator shall be a fast response stepper motor capable of stroking 90 degrees in 30 seconds for quick damper positioning to speed commissioning and troubleshooting tasks.
7. The controller shall determine airflow by dynamic pressure measurement using an integral dead-ended differential pressure transducer. The transducer shall be maintenance-free and shall not require air filters.
8. Each controller shall have the ability to automatically calibrate the flow sensor to eliminate pressure transducer offset error due to ambient temperature / humidity effects.
9. The controller shall utilize a proportional plus integration (PI) algorithm for the space temperature control loops.
10. Each controller shall continuously, adaptively tune the control algorithms to improve control and controller reliability through reduced actuator duty cycle. In addition, this tuning reduces commissioning costs, and eliminates the maintenance costs of manually re-tuning loops to compensate for seasonal or other load changes.
11. The controller shall provide the ability to download and upload VAV controller configuration files, both locally and via the communications network. Controllers shall be able to be loaded individually or as a group using a zone schedule generated table of controller parameters.
12. Control setpoint changes initiated over the network shall be written to PCV non-volatile memory to prevent loss of setpoint changes and to provide consistent operation in the event of communication failure.
13. The controller firmware shall be flash-upgradeable remotely via the communications bus to minimize costs of feature enhancements.
14. The controller shall provide fail-soft operation if the airflow signal becomes unreliable, by automatically reverting to a pressure-dependent control mode.

15. The controller shall interface with balancer tools that allow automatic recalculation of box flow pickup gain (“K” factor), and the ability to directly command the airflow control loop to the box minimum and maximum airflow setpoints.
16. Controller performance shall be self-documenting via on-board diagnostics. These diagnostics shall consist of control loop performance measurements executing at each control loop’s sample interval, which may be used to continuously monitor and document system performance. The PCV shall calculate exponentially weighted moving averages (EWMA) for each of the following. These metrics shall be available to the end user for efficient management of the VAV terminals.
    a. Absolute temperature loop error
    b. Signed temperature loop error
    c. Absolute airflow loop error
    d. Signed airflow loop error
    e. Average damper actuator duty cycle
17. The controller shall detect system error conditions to assist in managing the VAV zones. The error conditions shall consist of:
    a. Unreliable space temperature sensor
    b. Unreliable differential pressure sensor
    c. Starved box
    d. Actuator stall
    e. Insufficient cooling
    f. Insufficient heating
18. The controller shall provide a flow test function to view damper position vs. flow in a graphical format. The information would alert the user to check damper position. The PCV would also provide a method to calculate actuator duty cycle as an indicator of damper actuator runtime.
19. The controller shall provide a compliant interface for ASHRAE Standard 62-1989 (indoor air quality) and shall be capable of resetting the box minimum airflow based on the percent of outdoor air in the primary air stream.
20. The controller shall comply with ASHRAE Standard 90.1 (energy efficiency) by preventing simultaneous heating and cooling, and where the control strategy requires reset of airflow while in reheat, by modulating the box reheat device fully open prior to increasing the airflow in the heating sequence.
21. Inputs:
    a. Analog inputs with user defined ranges shall monitor the following analog signals, without the addition of equipment outside the terminal controller cabinet:
        1) 0-10 VDC Sensors
        2) 1000-ohm RTDs
        3) NTC Thermistors
    b. Binary inputs shall monitor dry contact closures. Input shall provide filtering to eliminate false signals resulting from input “bouncing.”
    c. For noise immunity, the inputs shall be internally isolated from power, communications, and output circuits.
    d. Provide side loop application for humidity control.
22. Outputs
    a. Analog outputs shall provide the following control outputs:
        1) 0-10 VDC
    b. Binary outputs shall provide a SPST Triac output rated for 500mA at 24 VAC.
    c. For noise immunity, the outputs shall be internally isolated from power, communications, and other output circuits.
23. Application Configuration
    a. The PCV shall be configured with a software tool that provides a simple Question/Answer format for developing applications and downloading.

24. Sensor Support
    a. The PCV shall communicate over the Sensor-Actuator Bus (SA Bus) with a Network Sensor.
    b. The PCV shall support an LCD display room sensor.
    c. The PCV shall also support standard room sensors as defined by analog input requirements.
    d. The PCV shall support humidity sensors defined by the AI side loop.
25. Mounting: The BAS contractor shall mount the VAV ASC to the VAV box in the field including the VAV ASC controller and connection of actuator to damper shaft and reheat valve actuator as specified on drawing. The VAV terminal manufacturer shall provide a multi-point, averaging, differential pressure sensor mounted on the inlet to each VAV box. The BAS contractor shall supply a line to low voltage transformer, of sufficient capacity, to power the VAV ASC plus all reheat valves and/or contactors and fan circuits associated with the VAV terminal and actuator assemblies. The BAS contractor shall provide all reheat control valves to the mechanical contractor for mounting and piping. The BAS contractor shall provide and install all wiring between the valve and VAV ASC controller and between the room sensor and the VAV ASC controller.

2.3 ROOM SENSOR: PROVIDE JCI NS-BTXXXXX-2 (NO SUBSTITUTIONS PERMITTED)

A. Sensors shall be provided with +/- 1-degree temperature adjustment and override button.
B. Provide for all rooms except CUH's, SUH's and exhaust fans.
C. Provide TE-6314P-1 with TE-1800-9600 mounting base for CUH's, SUH's and exhaust fans.

2.4 SOFTWARE: PROVIDE JCI LP-FXSWUPG-0 FX SERVER LICENSE SOFTWARE UPGRADE AND LP-FX40UPG-0 LICENSE SOFTWARE UPGRADE IN QUANTITIES AS REQUIRED TO UPGRADE ALL JACES IN THE DISTRICT TO THE CURRENT REVISION OF TRIDIUM SOFTWARE (NO SUBSTITUTIONS PERMITTED)

A. Controller and System HVAC Applications
    1. Include and implement the following capabilities from the control units if documented by the specified sequence of operations:
        a. Load Control Programs: Demand limiting, duty cycling, automatic time scheduling, start/stop time optimization, occupied/unoccupied setback/setup, DDC with PID, and trend logging.
        b. HVAC Control Programs: Optimal run time, supply-air reset, and enthalpy/economizer switchover.
        c. Boiler Control Programs: Boiler plant optimization with hot water supply reset, boiler and pump equipment selection and sequencing.
        d. Programming Application Features: Include trend point, alarm reporting, alarm lockout, weekly scheduling, staggered start, sequencing, anti-short cycling and calculated point.
    2. Controller and Network Setup Software
        a. Network management tools for N2 or BACnet protocol shall be provided including a network learn function, service pins, winks, and diagnostics.

2.5 CONTROL PANELS: PROVIDE JCI PAN-ENCXXXXWDP OF APPROPRIATE SIZE OR APPROVED EQUAL.

A. Unitized cabinet type for each system under automatic control with relays and controls mounted in cabinet and temperature indicators, pressure gages, pilot lights, push buttons and switches flush on cabinet panel face.
B. NEMA 250, general purpose utility enclosures with enameled finished face panel.
C. Provide straight screw driver latch (no keying) for all panels.

2.6 CONTROL VALVES: PROVIDE BELIMO B2/B3 CHARACTERIZED CONTROL VALVES AND BELIMO "F" SERIES BUTTERFLY VALVES OF APPROPRIATE SIZE AND TYPE (NO SUBSTITUTIONS PERMITTED). PROVIDE BELIMO LF/AF SPRING RETURN VALVE ACTUATORS OF APPROPRIATE SIZE AND TYPE (NO SUBSTITUTIONS PERMITTED)

A. Electronic, positive positioning, spring return, low voltage (24 VAC) actuators to be properly selected for the valve body and service.
B. Valve bodies to be 3-way mixing, 2-way normally open or normally closed to suit application. Bodies 2 inches and less to be 250 psig bronze, screwed connection, bronze seats, equal percentage plugs, stainless steel stems with Teflon packing. Over 2-inch bodies to be 125 psig iron, flanged connection with modified equal percent plug. Valve selection to be based on 3 psig drop across fully open valve.
C. The valves shall be sized by the control manufacturer and be provided with actuators of sufficient power for the duty intended. Valve body and actuator selection shall be sufficient to handle system pressure and shall close against the differential pressures to be encountered on the project.
D. Where required by the sequence of operation, valves shall be capable of being sequenced either with other valves or other actuated devices. Where such sequencing is required, the actual spring range, when adjusted for spring shift, shall be such that no overlapping occurs. In the event that spring shift causes an overlap, a pilot positioning operator shall be furnished.
E. Small Valves - ½-Inch through 2-Inch:
    1. Ball type.
    2. Valves shall be constructed with a two-piece cast brass body and screwed ends. Valves shall have removable packing gland with threaded cap for shaft seal. O-Ring type seals are unacceptable.
    3. Electric actuator shall be Belimo LF/AF series. Body rating shall be 400 psi at 50 degrees F. Body rating shall also meet or exceed ANSI B6.5 Class 250.
F. Valves - 2½-Inches and Above:
    1. Ball or butterfly type.
    2. Valves shall be constructed with a cast iron body and have flanged connections. Valves shall have removable packing gland with threaded cap for shaft seal.
    3. Electric actuators shall be Belimo PR Series type actuators.
    4. Ball and butterfly valves need to achieve proper Cv. by use of reduced size and reducers or reduced port.
G. All control valves shall fail safe by spring return as follows:
    1. Heating: Fails open (N.O.).
    2. Cooling: Fails closed (N.C.)
    3. VAV Box Valves shall fail to open.
H. Electronic Operators:
    1. Acceptable Manufacturers:
        a. Belimo.
        b. No Substitutions.
    2. Valves shall spring return to normal position as indicated on freeze, fire, or temperature protection.
        a. 2" and smaller shall be LF-24MFT/AFB24MFT series actuators and must be wired to controllers that are connected to emergency panels that are powered by the generator.
        b. 2-½" and larger shall be PR Series actuators and must be wired to controllers that are connected to emergency panels that are powered by the generator, they will not spring return they will fail to their current position.
    3. Select operator for full shut off at maximum pump differential pressure.

2.7 INTERIOR DAMPERS: PROVIDE JCI VD-1300 SERIES VOLUME CONTROL DAMPERS OF APPROPRIATE SIZE AND TYPE OR APPROVED EQUAL.

A. Acceptable Manufacturer:
   1. Johnson Controls, Inc.
   2. Ruskin.
   3. Pottorf.
B. Performance: Test in accordance with AMCA 500.
C. Frames: Galvanized steel welded or riveted with corner reinforcement.
D. Blades: Galvanized steel, maximum blade size 6 inches wide, 48 inches long, attached to minimum ½-inch shafts with set screws.
E. Blade Seals: Synthetic elastomeric or Neoprene mechanically attached, field replaceable.
F. Jamb Seals: Spring stainless steel.
G. Shaft Bearings: Graphite impregnated nylon sleeve, with thrust washers at bearings or lubricant free, stainless steel, single row, ground, flanged, radial, antifriction type with extended inner race.
H. Linkage Bearings: Graphite impregnated nylon.
I. Leakage: Less than 2 percent based on approach velocity of 2000 ft/min and 4 inches w.g.
J. Maximum Pressure Differential: 6 inches w.g.
K. Temperature Limits: -40 to 200 degrees F.

2.8 DAMPER OPERATORS: PROVIDE BELIMO DAMPER ACTUATORS OF APPROPRIATE SIZE (NO SUBSTITUTIONS PERMITTED)

A. Acceptable Manufacturers:
   1. Belimo (LF Series)
   2. No Substitutions.
B. General: Provide smooth proportional control with sufficient power for air velocities 20 percent greater than maximum design velocity and to provide tight seal against maximum system pressures. Provide spring return for two position control and for fail safe operation.
C. Electric Operators: Actuators shall use a brushless DC motor and be protected from overload at all angles of rotation. Run time shall be constant and independent of torque. If required, 2 SPDT auxiliary switches shall be provided.
D. Number: Sufficient to achieve unrestricted movement throughout damper range. Provide one damper operator for maximum 25 sq. ft. damper section.

2.9 INPUT/OUTPUT SENSORS

A. Electronic Sensors: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.
   1. Thermistor or Resistance Temperature Detectors temperature sensors as follows: Provide JCI TE-6300 series of appropriate type and size or approved equal.
      a. Accuracy: Plus, or minus .3 C F at calibration point.
      b. Wire: Twisted, shielded pair cable.
      c. Insertion Elements in Ducts: Single point, 8 inches long; use where not affected by temperature stratification or where ducts are smaller than 9 sq. ft.
      d. Averaging Elements in Ducts: 17-foot-long; use where prone to temperature stratification or where ducts are larger than 9 sq. ft. length as required.
      e. Insertion Elements for heating system: Brass well with minimum insertion length of 2-1/2 inches. Stainless steel wells are required for all chiller systems.
      f. Room Sensors: Cover to be blank, with plus/minus 3-degree setpoint adjustable, and/or with override button at Owners choice.
      g. Outside-Air Sensors: Watertight inlet fitting, shielded from direct sunlight.
      h. Room Security Sensors: Stainless steel cover plate with insulated back and security screws.

2. Static-Pressure Transmitter: Provide Veris PXPLX series of appropriate range or approved equal.
    a. Non-directional sensor with suitable range for expected input, and temperature compensated.
    b. Accuracy: 2 percent of full scale with repeatability of 0.5 percent.
    c. Output: 4 to 20 mA.
    d. Building Static-Pressure Range: 0 to 0.25-inch w.g.
    e. Duct Static-Pressure Range: 0 to 5 inches w.g.
3. Pressure Transmitters: Provide Veris PWLX series of appropriate range with AA16A bypass valve assembly (No Substitutions Permitted)
4. Direct acting for gas or liquid; range suitable for system; proportional output 4 to 20 MA. Water differential pressure sensors shall be as manufactured by Veris with a three-valve manifold.

B. Equipment operation sensors as follows: Provide Veris H708 current sensor of appropriate range or approved equal.
    1. Status inputs for Fans and Pumps: Current-sensing relay with current transformers, adjustable and set to 175 percent of rated motor current.
C. Carbon Dioxide Room Sensors: Provide JCI CD-W00-N0-1 series wall mounted CO2 sensor (No Substitutions Permitted).
D. Outside Air Humidity and Temperature Sensor: Provide JCI HE-68P3-0N000 series OA mounted humidity and temperature sensor (No Substitutions Permitted).
E. Outside Photocell: Provide Kele EM-24A2 series OA mounted photocell sensor or approved equal.

2.10 THERMOSTATS

A. Electric Low Limit Duct Thermostat: Provide JCI A70HA-1C series (No Substitutions Permitted)
    1. Snap acting, single pole, single throw, automatic reset switch which trips if temperature sensed across any 12 inches of bulb length is equal to or below setpoint.
    2. Bulb Length: Minimum 20 feet.
    3. Provide one thermostat for every 20 sq. ft. of coil surface.

2.11 MISCELLANEOUS DEVICES

A. Relays: Provide IDEC RR2P-ULAC24V series relay with corresponding SR2P-06 relay base (No Substitutions Permitted)
    1. All relays are to be installed in control panels. Relays in box (RIB's) are not acceptable.
    2. Control relays shall be UL listed plug-in type with dust cover. Contact rating, configuration, and coil voltage suitable for application. Relays to be IDEC RR2P-UL AC24V with SR2P-06 base.
B. Transformers and Power Supplies: Provide Core Components LE series transformers of appropriate size & type, or Core LD05763 Power Supply mounted in control panels or approved equal.
    1. Control transformers shall be UL listed, Class 2 current-limiting type, or shall be furnished with over-current protection in both primary and secondary circuits for Class 2 service.
    2. Unit output shall match the required output current and voltage requirements. Current output shall allow for a 50% safety factor. Output ripple shall be 3.0 mV maximum Peak-to-Peak. Regulation shall be 0.10% line and load combined, with 50 microsecond response time for 50% load changes. Unit shall have built-in over-voltage protection.
    3. Unit shall operate between 0° C and 50° C.
    4. Unit shall be UL recognized.
C. Ethernet Switch: Provide CDW FS105 5-Port 10/100MB Ethernet Switch or approved equal.
D. Water Flow Switch: Provide JCI F61KB-11C Water Flow Switch or approved equal.
E. Refrigerant Leak Detector: See section 15155 for requirements.
F. Push Button Switch: Provide Camden CM-9080 switch (DPDT momentary) with spring return and single gang brushed aluminum faceplate (No Substitutions Permitted).

G. Power Monitoring: Provide Veris E50H2A 5000 Amp BACnet Power Meter, U018-0002 CT transducers as required, AH04 Fuse Kit, & AE012 NEMA 4X Enclosure or approved equal.

2.12 INSERTION TURBINE FLOW METERS: PROVIDE ONICON F-1210 SERIES OF APPROPRIATE RANGE WITH INSTL2 HOT TAP INSTALLATION KIT (NO SUBSTITUTIONS PERMITTED)

A. Meter shall be ONICON Incorporated model F1210.
B. Accuracy: ± 0.5% of recovery at calibrated velocity.
C. Supply voltage: 24 ± 4V AC/DC at 50mA.
D. Accessories: Cable with connector.
E. Output signal: 0-15V pulse or analog/digital.
F. Provide a minimum of one in main building loop.

2.13 COMMUNICATION CABLE

A. Provide plenum rated when running above ceilings.
B. Exposed cable in mechanical, storage, electrical, etc. rooms to run in minimum ¾" conduit.
C. Cable drops to unit ventilators are to be concealed in pipe chases (either sheet metal by mechanical contractor or architectural chases provided by general contractor) and run in minimum ¾" conduit to allow future removal of cable. Horizontal runs of cable between unit ventilators and in shelving cabinets to also be run in minimum ¾" conduit. Exposed cable drops in Classrooms are not allowed. See electrical drawings of additional requirements.
D. Where exposed cable drops in occupied areas are unavoidable cable to be run in raceway/wiremold.

2.14 CONTACTORS

A. Provide definite purpose controllers equal to Siemens, Square D or Furnas Model 423F35AF. Provide 2, 3 or 4-pole as required by site conditions.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify existing conditions before starting work.
B. Verify that conditioned power supply is available to the control units and to the operator work station. Verify that field end devices, wiring, and pneumatic tubing is installed prior to installation proceeding.

3.2 INSTALLATION

A. Install control units and other hardware in position on permanent walls where not subject to excessive vibration.
B. Provide metal thermostat/sensor guards for all thermostats/sensors located in unsupervised areas. Plastic guards are not acceptable.
C. Install software in control units and in operator workstation. Implement all features of programs to specified requirements and appropriate to sequence of operation. Refer to Section 17600.
D. Electrical material and installation shall be in accordance with appropriate requirements of Division 16.
E. Provide liquid tight flexible conduit for all BAS connections to equipment located in the Boiler Room and Mechanical Room.
F. Provide liquid tight flexible conduit for all equipment with vibration isolation.
G. BAS Wiring
    1. All conduit, wiring, accessories and wiring connections required for the installation of the BAS, as herein specified, shall be provided by the BAS Contractor unless specifically shown on the Electrical Drawings under Division 16 Electrical. All wiring shall comply with the requirements of applicable portions of Division 16 and all local and national electric codes, unless specified otherwise in this section.
    2. All BAS wiring materials and installation methods shall comply with BAS manufacturer recommendations.

3. The sizing type and provision of cable, conduit, cable trays, and trunking shall be the design responsibility of the BAS Contractor. If complications arise, however, due to the incorrect selection of cable, cable trays, trunking and/or conduit by the BAS Contractor, the Contractor shall be responsible for all costs incurred in replacing the selected components.

H. BAS Raceway
   1. All wiring in rooms (Mechanical, Boiler, Mezzanine, Storage, Etc.) with no drop ceiling shall be installed in conduit. Wiremold or equal raceway shall be used in occupied spaces and below drop ceiling. Minimum control wiring conduit size ¾ inch.
   2. All conduits and raceways shall be installed level, plumb, at right angles to the building lines and shall follow the contours of the surface to which they are attached.
   3. Flexible Metal Conduit shall be used for vibration isolation and shall be limited to 3 feet in length when terminating to vibrating equipment. Flexible Metal Conduit may be used within partition walls. Flexible Metal Conduit shall be UL listed."

I. Provide setup time to configure Owner's smartphones for remote web access.

3.3 MANUFACTURER'S FIELD SERVICES

A. Prepare and start systems.
B. Start and commission systems. Allow sufficient time for start-up and commissioning prior to placing control systems in permanent operation.

3.4 TRAINING

A. Provide competent service engineer to instruct Owner's representative in operation of automatic control systems. Onsite training shall consist of 8 hours in two 4 hours increments. This time shall be for training only, not maintenance of system. Contractor shall prepare a time log sheet, obtaining owner's signature after training sessions and provide updates to owner after each session.

3.5 INPUT/OUTPUT SCHEDULES

A. See Specification Section 17600 "Sequence of Operation for HVAC controls".

END OF SECTION

SECTION 17150

VARIABLE FREQUENCY DRIVE

PART 1 – GENERAL

1.1 WORK INCLUDED

A. Complete adjustable frequency drive controls consisting of pulse width modulating or step type inverters for use on each standard NEMA Design B induction motor, for Exhaust Fans, Air Handling Units, and all Pumps. **Each drive to have a separate mechanical bypass.**

B. Adjustable frequency drive system designed for continuous duty and suitable for use on motors that are direct connected.

1.2 RELATED WORK

A. Section 15540 - HVAC Pumps

B. Section 15870 – Power Ventilators.

1.3 QUALITY ASSURANCE

A. Units: UL and ETL listed.

1.4 QUALIFICATIONS

A. The supplier of the assembly shall be the manufacturer of the electromechanical power components used within the assembly, such as bypass contactors, power distribution circuit breakers, when specified. These parts, when specified, shall have a commonality with other manufacturer's products.

B. For the equipment specified herein, the manufacturer shall be ISO 9002 certified.

C. The supplier of this equipment shall have produced similar electrical equipment for a minimum period of ten (10) years. When requested by the Engineer, an acceptable list of installations with similar equipment shall be provided demonstrating compliance with this requirement.

D. Approved Manufacturer: Provide ABB, or Johnson Controls Inc. next generation VSD Series II Variable Speed Drives powered by Eaton technology. All drives shall be furnished with Enclosed IntelliPass complete with third contactor for drive isolation and separate mechanical manual bypass switch. Provide all drives with NEMA Type 1 (IP21) enclosure. No substitutions or deviations from the above will be permitted.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Equipment shall be handled and stored in accordance with manufacturer's instructions. One (1) copy of these instructions shall be included with the equipment at time of shipment.

B. Electrical contractor shall receive, mount and power wire the frequency drives furnished by the Building Automation System (BAS) Contractor. BAS shall be responsible for temperature controls wiring to the drives. BAS shall furnish the drives for the two building pumps (BWP-1 and BWP-2), one (1) chiller pump (CHP-1)m three (3) boiler circulation pumps (BCP-1, BCP-2 and BCP-3), and the four (4) exhaust fans (EF-5, EF-6, EF-8 and EF-13). Verify motor size and voltage before ordering drives. Note all drives shall be furnished with separate mechanical bypass.

1.6 OPERATION AND MAINTENANCE MANUALS

A. Two (2) copies of the equipment operation and maintenance manuals shall be provided. Operation and maintenance manuals shall include the following information:

1. Instruction books
2. Recommended renewal parts list.
3. Drawings and information required.

1.7 REGULATORY REQUIREMENTS

A. Conform to International 2015 Mechanical Code.

PART 2 – PRODUCTS

2.1 GENERAL

A. Where shown on the drawings, adjustable frequency drives 1 through 150 HP shall have the following features:

1. The VFD's shall be rated for 480 VAC (optional input voltages of 208 VAC through 60 HP, 240 VAC through 75 HP). The VFD shall provide microprocessor-based control for three-phase induction motors. The controller's full load output current rating shall be based on variable torque application at 40° C ambient and 1-16 kHz switching frequency below 50 HP and 1-10 kHz 50 HP and above to reduce motor noise and avoid increased motor losses.
2. The VFD's shall be of the Pulse Width Modulated (PWM) design converting the utility input voltage and frequency to a variable voltage and frequency output via a two-step operation. Adjustable Current Source VFD's are not accepted. Insulated Gate Bipolar Transistors (IGBTs) shall be used in the inverter section. Bipolar Junction Transistors, GTO's or SCR's are not accepted. The VFD shall run at the above listed switching frequencies.
3. The VFD's shall have efficiency at full load and speed that exceeds 95% for VFD's below 15 HP and 97% for drives 15 HP and above. The efficiency shall exceed 90% at 50% speed and load.
4. The VFD's shall maintain a minimum line side displacement power factor of 0.96, regardless of speed and load
5. The VFD's shall have a one (1) minute overload current rating of 110% for variable torque applications.
6. The VFD's shall be capable of operating any NEMA design B squirrel cage induction motor, regardless of manufacturer, with a horsepower and current rating within the capacity of the VFD.
7. The VFD's shall have an integral EMI/RFI filter as standard.
8. The VFD's shall limit harmonic distortion reflected onto the utility system to voltage and current levels as defined by IEEE 519-1992 for general systems applications, by utilizing the standard 3% nominal impedance integral ac three-phase line reactor. DC link chokes are not accepted.
9. Any harmonic calculations shall be done based on the KVA capacity, X/R ratio and the impedance of the utility transformer feeding the installation, as noted on the drawings, and the total system load. The calculations shall be made with the point of common coupling (PCC) being the point where the utility feeds multiple customers.
10. Total harmonic distortion shall be calculated under worst case conditions in accordance with the procedure outlined in IEEE 519-1992. Copies of these calculations are to be made available upon request. The contractor shall provide any needed information to the VFD supplier three (3) weeks prior to requiring harmonic calculations.
11. The system containing the VFD's shall comply with the 5% level of total harmonic distortion of line voltage and the line current limits as defined in IEEE 519-1992. If the system cannot meet the harmonic levels with the VFD's provided with the standard input line reactor or optional input isolation transformer, the VFD manufacturer shall supply an eighteen pulse, multiple bridge rectifier ac to dc conversion section with phase shifting transformer for all drives above 75 HP. This eighteen-pulse rectifier converter shall result in a multiple pulse current waveform that will more nearly approximate a true sine wave to reduce voltage harmonic content on the utility line. The phase shifting transformer shall be of a single winding type to optimize its KVA rating and harmonic cancellation capability. Harmonic filters are not accepted above 75 HP.

12. The VFD's shall be able to start into a spinning motor. The VFD's shall be able to determine the motor speed in any direction and resume operation without tripping. If the motor is spinning in the reverse direction, the VFD's shall start into the motor in the reverse direction, bring the motor to a controlled stop, and then accelerate the motor to the preset speed. Standard operating conditions shall be:
    a. Incoming Power: Three-phase, 208 / 240 / 480 (+10% to -15%) and 50/60 Hz (+/-5 Hz) power to a fixed potential DC bus level.
    b. Frequency stability of +/-0.05% for 24 hours with voltage regulation of +/-1% of maximum rated output voltage.
    c. Speed regulation of +/- 0.5% of base speed.
    d. Load inertia dependent carryover (ride through) during utility loss.
    e. Insensitive to input line rotation.
    f. Humidity: 0 to 95% (non-condensing and non-corrosive).
    g. Altitude: 0 to 3,300 feet (1000 meters) above sea level.
    h. Ambient Temperature: -10° to 40° C (VT).
    i. Storage Temperature: -40° to 70° C.
13. Control Functions
    a. Frequently accessed VFD programmable parameters shall be adjustable from a digital operator keypad located on the front of the VFD. The VFD'S shall have a 3-line alphanumeric programmable display with status indicators. Keypads must use plain English words for parameters, status, and diagnostic messages. Keypads that are difficult to read or understand are not accepted, and particularly those that use alphanumeric code and tables. Keypads shall be adjustable for contrast with large characters easily visible in normal ambient light.
    b. The keypad shall include a Hand-Off-Auto membrane selection and an Inverter/Bypass membrane selection. When in "Hand" the VFD will be started and the speed will be controlled from the up/down arrows. When in "Off", the VFD will be stopped. In "Auto", the VFD will start via an external contact closure or a communication network and the VFD speed will be controlled via an external speed reference.
    c. The keypad shall have copy / paste capability.
    d. Upon initial power up of the VFD, the keypad shall display a startup guide that will sequence all the necessary parameter adjustments for general start up.
    e. Standard advanced programming and trouble-shooting functions shall be available by using a personal computer's RS-232 port and Windows™ based software. In addition, the software shall permit control and monitoring via the VFD's RS232 port. The manufacturer shall supply a diskette with the required software. An easily understood instruction manual and software help screens shall also be provided. The computer software shall be used for modifying the drive setup and reviewing diagnostic and trend information as outlined in this section through section 18.
    f. The operator shall be able to scroll through the keypad menu to choose between the following:
        1) Parameter Menu
        2) Keypad Control
        3) System Menu
        4) Expander Boards
        5) Monitoring Menu
        6) Operate Menu
    g. The following setups and adjustments, at a minimum, are to be available:
        1) Start command from keypad, remote or communications port
        2) Speed command from keypad, remote or communications port
        3) Motor direction selection
        4) Maximum and minimum speed limits
        5) Acceleration and deceleration times, two settable ranges
        6) Critical (skip) frequency avoidance
        7) Torque limit

8) Multiple attempt restart function
9) Multiple preset speeds adjustment
10) Catch a spinning motor start or normal start selection
11) Programmable analog output

14. The VFD shall have the following system interfaces:
    a. Inputs – A minimum of six (6) programmable digital inputs, two (2) analog inputs and serial communications interface shall be provided with the following available as a minimum:
        1) Remote manual/auto
        2) Remote start/stop
        3) Remote forward/reverse
        4) Remote preset speeds
        5) Remote external trip
        6) Remote fault reset
        7) Process control speed reference interface, 4-20mAdc
        8) Potentiometer or process control speed reference interface, 0 -10Vdc
        9) RS232 programming and operation interface port
    b. Outputs – A minimum of two (2) discrete programmable digital outputs, one (1) programmable open collector output, and one (1) programmable analog output shall be provided, with the following available at minimum.
        1) Programmable relay outputs with one (1) set of Form C contacts for each, selectable with the following available at minimum:
            a) Fault
            b) Run
            c) Ready
            d) Reversing
            e) Jogging
            f) At speed
            g) In torque limit
            h) Motor rotation direction opposite of commanded
            i) Over temperature
        2) Programmable open collector output with available 24Vdc power supply and selectable with the following available at minimum:
            a) Fault
            b) Run
            c) Ready
            d) Reversing
            e) Jogging
            f) At speed
            g) In torque limit
            h) Motor rotation direction opposite of commanded
            i) Over temperature
        3) Programmable analog output signal, selectable with the following available at minimum:
            a) Output frequency
            b) Frequency reference
            c) Motor speed
            d) Output current
            e) Motor torque
            f) Motor power
            g) Motor voltage
            h) DC link voltage
            i) PID controller reference value
            j) PID controller actual value 1

k) PID controller actual value 2
l) PID controller error value
m) PID controller output

c. Capability of two additional expandable I/O interface cards. Upon installation, software shall automatically identify the interface card and activate the appropriate parameters.

15. Monitoring and Displays
    a. The VFD's display shall be a LCD type capable of displaying three (3) lines of text and the following thirteen (13) status indicators:
        1) Run
        2) Forward
        3) Reverse
        4) Stop
        5) Ready
        6) Alarm
        7) Fault
        8) I/O Terminal
        9) Keypad
        10) Bus / Comm.
        11) Hand
        12) Auto
        13) Off
    b. The VFD's keypad shall be capable of displaying the following monitoring functions at a minimum:
        1) Motor Speed (RPM and %)
        2) Frequency reference
        3) Output frequency
        4) Motor current
        5) Motor torque
        6) Motor power
        7) Motor voltage
        8) DC-link voltage
        9) Heat sink temperature
        10) Motor run time (re-settable)
        11) Total operating days counter
        12) Operating hours (re-settable)
        13) Total megawatt hours
        14) Megawatt hours (re-settable)
        15) Voltage level of analog input
        16) Current level of analog input
        17) Digital inputs status
        18) Digital and relay outputs status
        19) Motor temperature rise
        20) PID references
16. Protective Functions
    a. The VFD shall include the following protective features at minimum:
        1) Over current
        2) Overvoltage
        3) System fault
        4) Under voltage
        5) Input line supervision
        6) Output phase supervision
        7) Under temperature
        8) Over temperature
        9) Motor stalled

10) Motor over temperature
11) Motor under load
12) Logic voltage failure
13) Microprocessor failure
14) Brake chopper supervision
15) DC Injection braking

b. The VFD shall provide ground fault protection during power-up, starting, and running. VFD's with no ground fault protection during running are not accepted.

17. Diagnostic Features
    a. Active Faults
        1) The last 10 faults shall be recorded and stored in sequential order
        2) Fault code and description of fault shall be displayed on the keypad.
        3) Fault or alarm LED shall blink
        4) Display drive data at time of fault
        5) In the event several faults occur simultaneously, the sequence of active faults shall be viewable.
    b. Fault History
        1) The last 30 faults shall be recorded and stored in sequential order.
        2) Display drive data at time of fault
18. Additional features included in the VFD'S:
    a. A HMCP or MMP device shall provide a disconnect means with provision for lockout. Disconnect handles mounted on the door will not be accepted. The handle position shall indicate ON and OFF condition. Operator shall be interlocked with cover to prevent opening with disconnect in the ON position.
    b. A complete factory wired and tested bypass system consisting of an output contactor and bypass contactor that is electrically and mechanically interlocked. Both contactors must to be fully rated at the current of the drive and motor.
    c. Optional third contactor to allow the VFD to completely disconnect all three phases from the line for maximum drive isolation. Fused drive isolation must also be available as an option.
    d. The following indicating lights shall be provided on the keypad.
        1) Drive/Bypass Ready (Flashing in Bypass Mode)
        2) Drive/Bypass Run
        3) Drive Fault
    e. The current withstand rating of the drive shall be 100,000 AIC. The bypass shall have an interrupting capacity of 65,000 AIC or greater. The combined withstand rating of drive and bypass must be 65,000 AIC or higher.
    f. Communication card for interface with Johnson Controls FX control system SA bus or BACnet MSTP.
    g. The VFD shall have a cooling fan that is field replaceable using non-screw accessibility.
19. Enclosure
    a. Two- or three-contactor design utilizing low voltage coils.
    b. Drive and bypass fully integrated. Bypass configured between the control and power sections of the VFD.
    c. HOA and bypass integrated into the keypad design.
    d. The VFD and bypass shall be designed in a NEMA Type 1 enclosure to provide enhanced protection against radiated EMI/RFI.
    e. The VFD shall have complete front accessibility with easily removable assemblies.
    f. Cable entry shall be top or bottom entry.
20. The VFD manufacturer shall maintain, as part of a national network, engineering service facilities within 250 miles of project to provide service.

21. Factory Testing
    a. The following standard factory tests shall be performed on the equipment provided under this section. All tests shall be in accordance with the latest version of UL and NEMA standards.
        1) All printed circuit boards shall be functionally tested via automatic test equipment prior to unit installation.
        2) All final assemblies shall be tested at full load with application of line-to-line and line-to-ground bolted faults. The Adjustable Frequency Drive shall trip electronically without device failure.
        3) After all tests have been performed; each VFD shall undergo a burn-in test. The drive shall be burned in at 100% inductive or motor load without an unscheduled shutdown.
        4) After the burn-in cycle is complete, each VFD shall be put through a motor load test before inspection and shipping.
    b. The manufacturer shall provide three (3) certified copies of factory test reports.
    c. All testing and manufacturing procedures shall be ISO 9002 certified.
22. Field Quality Control
    a. Provide the services of a qualified manufacturer's employed Field Service Engineer or authorized service representative if needed to assist the Contractor in installation and start-up of the equipment specified under this section. The manufacturer's service representative shall provide technical direction and assistance to the Contractor in general assembly of the equipment, installation as specified in manufacturer’s installation instructions, wiring, application dependent adjustments, and verification of proper VFD operation.
    b. The following minimum work shall be performed by the Contractor under the technical direction of the manufacturer's service representative.
        1) Inspection and final adjustments.
        2) Operational and functional checks of VFD’S and spare parts.
        3) The contractor shall certify that he has read the drive manufacturer’s installation instructions and has installed the VFD in accordance with those instructions.
    c. The Contractor shall provide two (2) copies of the manufacturer's field start-up report before final payment is made.
23. Maintenance/Warranty Service
    a. Warranty is thirty-six (36) months from the date of shipment and covers the factory repair or replacement of the defective unit.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Verify existing conditions before starting work.
B. Verify that conditioned power supply is available to the control units and to the operator work station. Verify that field end devices, wiring, and pneumatic tubing is installed prior to installation proceeding.

3.2 INSTALLATION

A. Install control units and other hardware in position on permanent walls where not subject to excessive vibration.
B. Install software in control units and in operator workstation. Implement all features of programs to specified requirements and appropriate to sequence of operation.
C. Electrical material and installation shall be in accordance with appropriate requirements of Division 16.

3.3 MANUFACTURER'S FIELD SERVICES

A. Prepare and start systems.
B. Start and commission systems. Allow sufficient time for start-up and commissioning prior to placing control systems in permanent operation.

3.4 TRAINING

A. The manufacturer shall provide start-up commissioning of the VFD and its optional circuits by a factory certified service technician who is experienced in start-up and repair services. Sales personnel and other agents who are not factory certified shall not be acceptable as commissioning agents. Start-up services shall include checking for verification of proper operation and installation for the VFD, its options and its interface wiring to the building automation system.

3.5 EXAMINATION

A. Contractor to verify that job site conditions for installation meet factory recommended and code-required conditions for VFD installation prior to start-up, including clearance spacing, temperature, contamination, dust, and moisture of the environment. Separate conduit installation of the motor wiring, power wiring, and control wiring, and installation per the manufacturer's recommendations shall be verified.
B. The VFD is to be covered and protected from installation dust and contamination until the environment is cleaned and ready for operation. The VFD shall not be operated while the unit is covered.

3.6 INTERFACING

A. BAS Contractor shall coordinate with Electrical Contractor to ensure all power and control interlocks are properly made in order to provide complete operating system.
B. Provide electrical and control diagrams to respective Electrical and BAS Contractors showing all interlocking wiring and control input locations.
C. BAS control wiring conduit will be furnished and installed by BAS Contractor.

END OF SECTION

SECTION 17155

REFRIGERATION MANAGEMENT

PART 1 - GENERAL

1.1 REFERENCES

A. ASHRAE 15-2001 - Safety Code for Mechanical Refrigeration.
B. ANSI/ASHRAE 34-2001 - Number Designation and Safety Classification of Refrigerants.
C. ASHRAE Guideline 3-1990 - Reducing Emissions of Fully Halogenated Chlorofluorocarbon (CFC) Refrigerants in Refrigeration and Air-conditioning Equipment and Applications.
D. ANSI/ASME SEC 8 - Boiler and Pressure Vessel Code.

1.2 SCOPE

A. The purpose of this Mechanical Equipment Room (MER) Refrigerant Management System is to provide the mechanical equipment room and its occupants with safe and hygienic environmental conditions per ASHRAE 15-2001 - Safety Code for Mechanical Refrigeration. Additionally, it shall help to eliminate or minimize the release of refrigerants to the atmosphere and maintain equipment operating efficiencies to minimize the environmental impact of equipment operation per ASHRAE Guideline 3-1990 - Reducing Emissions of Fully Halogenated Chlorofluorocarbon (CFC) Refrigerants in Refrigeration and Air-conditioning Equipment and Applications.

1.3 WARRANTY

A. All components, parts and assemblies guaranteed against defects in material and workmanship for one (1) year in accordance with General Requirements - completion and acceptance by Owner and Architect/Engineer of total system for start of guaranty period.
B. During first year, BAS Contractor provides all software improvements to programs that are part of system that BAS manufacturer may make commercially available, at no additional cost to the Owner.
C. BAS Contractor also guarantees all water piping modification, temperature control equipment, all conduit, wiring and electrical devices he installed under BAS contract.
D. Following procedures govern warranty period:
    1. Within 15 days after total BAS acceptance by Owner and Architect/Engineer, BAS Contractor will initiate warranty period by transmitting to Owner and Architect/Engineer commencement notification in writing.
    2. Within 30 days of end of warranty period, BAS Contractor notifies Owner that one (1) year warranty is almost complete.
E. BAS Contractor's warranty covers all service, labor and parts, incidental to contrived proper performance of BAS and devices during warranty period.
F. Normal servicing of system components not considered BAS Contractor's responsibility after one (1) year warranty period, unless contracted for by Owner.
G. Six months into warranty, BAS Contractor to recalibrate all refrigerant monitoring points.
H. At completion of warranty, BAS Contractor furnishes list of tasks recommended, frequency of preventative maintenance and tools to perform tasks recommended.
I. One-year warranty is for all parts and labor, for specified equipment and systems called for in Division 17.
J. Contractor shall provide for refrigerant monitoring system start-up.

1.4 REGULATORY REQUIREMENTS

A. International Mechanical Code 2015.
B. ETL listed to UL 61010-1.

1.5 MAINTENANCE SERVICE

A. Normal servicing of system components for a one (1) year warranty period, from time of substantial completion.

1.6 SUBMITTALS

A. Submit under requirements indicated under Division 1 General Requirements for equipment submittals.

PART 2 - PRODUCTS

2.1 PRODUCTS

A. Refrigerant Gas Detector/Transmitter
   1. Provide a Refrigerant Network per refrigerant and/or per chiller
   2. Meet the following requirements:
      a. General:
         1) Refrigerant detector/transmitter will be powered by the control panel's power output or be powered by an external power supply. Back lit LCD and keypad will be present on refrigerant detector/transmitter.
      b. Refrigerant protection and control:
         1) Provide a low voltage, dual relay Refrigerant (REF) detector, controller and transducer with selectable 4-20 mA output, buzzer and digital display options. Electronic detection system used to measure the concentration of refrigerant gas and provide feedback and automatic exhaust fan control to help reduce refrigerant gas concentrations. Unit is a low-level meter capable of detecting several refrigerants including R-22, R-134A, R404A, R407C and R410A.
      c. Selectable options include:
         1) Fan relay actuation: selectable at 100 (default), 150, 200, 250, 300, 350ppm.
         2) Output: Fan relay, Alarm relay and 4-20 mA current loop.
         3) Controls: Digital display (0-1,000 ppm), buzzer, fan delay, fan minimum runtime.
      d. Specifications:
         1) Power: 3 W (max) from 12 to 24 VAC or 12 to 32 VDC.
         2) Current @ 24 VDC: 75 mA in alarm, 50 mA fan relay on and 23 mA stand by.
         3) Size: 4½-inch x 2⅛-inch.
         4) Connections: plugs/terminals.
         5) Fan relay: 5 A, 240 VAC, pilot duty, SPDT, latching or non-latching.
         6) Fan relay actuation: selectable at "dIS" (disabled), 100 (default), 150, 200, 250, 300, 350 ppm.
         7) Fan Delay Settings of 0, 1, 3 (default), 5 and 10 minutes.
         8) Fan Minimum Runtime settings are 0 (default), 3, 5, 10 or 15 minutes.
         9) Alarm relay: 0.5A 120 V, 60 VA.
         10) Alarm relay actuation: selectable N.O. default or N.C.
         11) Alarm relay settings: "dIS", 100, 125, 150, 200, 300 (default), 400, 500 or 600 ppm.
         12) Current Loop, 4-20 mA for 0-1,000 ppm.
         13) Operating Environment: 0°F to 125°F, 10-to-90% RH non-condensing.
         14) Macurco RD-6, no substitutions.

B. Strobe Horn
   1. Meet the following requirements:
      a. Provide audible and visual alarm indicators inside and outside each entrance to mechanical room (per ASHRAE 8.11.2.1.). Strobe horn will be activated by the relay of the Refrigerant Monitor, Control panel or the Annunciator panel.
      b. Features and Specifications:
         1) Flexible optic design to meet or exceed the light output on vertical/horizontal dispersion.
         2) Strobe Candela: Adjustable at 15, 30, 75 or 110cd (based on test result with clear lens cover).
         3) Adjustable two (2) audible tone settings: Continuous (high/low) / Temporal 4 (high/low).
         4) 20ms pulse duration.
         5) Low Current Draw.
         6) High power cool white LED is used.
         7) Strobe flash rate: one (1) flash per second.
         8) Nominal Voltage: Regulated VDC.
         9) Operating Voltage: 16 to 33 VDC.

10) Operating Environment: 32°F to 120°F, 10-to-93% RH.
11) Equal to Macurco Series HS.

C. Transformer
   1. Provide a transformer sized to properly address power requirements of the network.

PART 3 - EXECUTION

3.1 REFRIGERANT CONCENTRATION MONITORING

A. The Mechanical Equipment Room Refrigerant Management System shall monitor the operation of each Refrigerant Concentration Monitor for control and logging as follows:
   1. Initiate emergency ventilation sequence in section 3.2 section B of this specification.
   2. Instantaneous refrigerant concentration in Parts Per Million (ppm).
   3. Activate exhaust fan through relays.
   4. Activate audible and visual alarms to activate the external strobe horn when concentration reaches levels as specified by refrigerant used so that all persons unprotected can escape within 15 minutes without experiencing health impairing or permanent health effects.
   5. The BAS system shall maintain reports for operator viewing to assist in refrigerant management. As a minimum the BAS shall log the data listed below. All monthly data shall be logged in the BAS systems for 12 months.
      a. Equipment Room Refrigerant Concentration: current, daily maximum and average, monthly maximum and average.
      b. Chiller Starts & Run Time: daily and monthly totals
      c. Chiller Purge Exhaust Compressor Starts and Run Time: daily and monthly totals (Note: Applicable for Low Pressure Refrigerant Chillers Only)
      d. Chiller Average Run Load Amperage: current, daily average and monthly average.
      e. Chiller Setpoint: current, daily average and monthly average.
      f. Leaving Chilled Water Temperature: current, daily average and monthly average.
      g. Difference Between Entering and Leaving Chilled Water Temperatures: current, daily average and monthly average.
      h. Evaporator Refrigerant Temperature: current, daily average and monthly average.
      i. Chilled Water to Refrigerant Temperature Approach: current, daily average and monthly average.
      j. Condenser Refrigerant Temperature: current, daily average and monthly average.

3.2 CHILLER EQUIPMENT ROOM VENTILATION

A. Modify existing chiller equipment room ventilation system with sensors/equipment specified herein to meet the specified sequence of operation in Section 17600 – Sequence of Operation.

END OF SECTION

SECTION 17600

SEQUENCE OF OPERATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. General HVAC Alarm Sequences.
B. Additional Controls and Alarms.
C. Building Heating/Cooling System Control.
D. ACV-1 Control Valves.
E. Domestic Hot Water System Control (Building).
F. Domestic Hot Water System Control (Gym).
G. Fin Tube Radiation and/or Convector Control.
H. Single Zone Air Handling Unit Control.
I. Variable Air Volume Air Handling Unit Control.
J. Variable Air Volume Box Control with Hot Water Coil Control.
K. Fire Shut Down of Air Supply Units Over 2000 CFM.
L. Hot Water Coil (Duct Mounted) and Motorized Damper Control.
M. Miscellaneous Exhaust Fan Control.
N. Building Excess Pressure Control.
O. Unit Heater SUH and CUH Control.
P. Vertical Classroom Unit Ventilator Control.
Q. Fan Coil Unit Control.
R. Refrigerant Monitor and Ventilation Control.
S. Power Monitoring / Phase Monitoring and Control System.
T. Outside Lighting Control
U. Electric Water Coolers
V. Generator

1.2 RELATED WORK

A. Division 17 - Building Automation System.

1.3 SYSTEM DESCRIPTION

A. This section defines the manner and method by which controls function. Requirements for each type of control system operation are specified. Equipment, devices and system components required for control systems are specified in other sections.

1.4 SUBMITTALS

A. Submit under provisions of the general conditions and general requirements of the contract.
B. Submit diagrams indicating mechanical systems controlled and control system components. Label with settings, adjustable range of control and limits. Include written description of control sequence.
C. Include flow diagrams for each control system, graphically depicting control logic.
D. Include draft copies of graphic displays indicating mechanical system components, control system components and controlled function status and value.
E. Contractor shall review all shop drawings prior to submitting them for Architect/ Engineer's review. Contractor shall stamp each shop drawing to certify that he has reviewed it. - Engineer will not check any shop drawings that contractor has not stamped with his review certification.

1.5 PROJECT RECORD DOCUMENTS

A. Submit documents under provisions of the general conditions and general requirements of the contract.
B. Accurately record actual setpoints and settings of controls, including changes to sequences made after submission of shop drawings.

SECTION 17600

SEQUENCE OF OPERATION

PART 2 - PRODUCTS

(Not Used.)

PART 3 - EXECUTION

3.1 SCOPE OF WORK

A. This sequence of operation section is inclusive of all requirements of all Division 17 and specified related sections.
B. There is specific information in the other section of this specification that directly affects the scope of work required for this sequence of operation: Especially, but not limited to, the system description, scope of work and schedule requirements set forth in Division 17.
C. Any contradictory information/requirements between sections shall be interpreted to mean that the most stringent, safe or costly requirement shall be included in the scope of work, unless identified by the BAS contractor, in writing, prior to bidding and specifically directed otherwise, in writing, by the owner/architect/engineer.
D. Failure of the contractor to read and understand all sections of this specification and the contract documents shall not be grounds for any additional cost to the owner for materials and labor required to meet the requirements of the contract documents.
E. The BAS contractor for this contract shall furnish and install all new controls for All HVAC equipment in the building in compliance with the controls sequences of operation described below (the BAS Contractor shall obtain any programs the owner has prior to building any of the programs below and modify them as required to meet the sequence, any program the owner doesn't have will have to be completely built by the BAS Contractor). Any equipment that is not specifically addressed below shall be provided with complete controls based on the most stringent or greatest cost sequence described below.
F. The BAS contractor shall provide a color graphical representation of each piece of equipment and each system. This is to include all pumps, boilers, chillers, air handling units, unit ventilators, fan coils, fan powered VAV boxes, cabinet/suspended unit heats, etc. Also "System" graphics showing air handling unit systems, heating/cooling system with pumps, boilers, and chiller plant with schematic piping diagram indicating all temperature, status and alarm conditions of all equipment. When the operator double clicks on pumps, boilers, or chillers a graphic representation of the equipment shall be displayed and all BACnet and Modbus points shall also be displayed.
G. Additional Requirement:
    1. See drawings and flow diagrams for additional requirements.
    2. The BAS contractor may use a BACNET, MODBUS or Lontalk gateway to provide additional generator, transfer switch, exhaust fan, supply and return blower, refrigerant monitor, chiller, boiler and pump points. The BAS contractor shall provide and pay for all necessary material and labor to achieve the interface, including but not limited to the generator, transfer switch, exhaust fan, supply and return blower, refrigerant monitor, chiller, boiler or pump manufacturer's gateway and necessary programming.

3.2 SEQUENCE OF OPERATION

A. General HVAC Alarm Sequences
    1. The web server shall provide complete alarm management and logging for every setpoint in the system. Every setpoint shall have an operator adjustable range for alarming that can be easily changed for high and low alarm values by the operator using pull-down menus on the graphic screen. Provide multi-level alarming capability for every setpoint or end device variable with the following minimum capabilities:
        a. Critical Alarm:
            1) Audible/visual alarm is initiated at LAN based workstations.
            2) Alarm is logged to history file
            3) Email is sent.

b. Non-Critical Alarm:
   1) Audible/visual alarm is initiated at LAN based workstation.
   2) Alarm is logged to history file.
c. Alarm Acknowledgement:
   1) Alarms are acknowledged by operator at the OWS or and Web Interface
   2) Operator ID is logged with alarm acknowledgment
   3) Alarm acknowledgment shall include a comment field to state the action taken
   4) The comment field shall be a continuous log allowing multiple operators to add comments to the alarm
d. Email Alarms:
   1) Each alarm type can be configured uniquely
   2) Emails will cascade to different operators on a time delay schedule if not acknowledged

B. Additional Controls and Alarms
   1. All control wiring and interlock wiring for boiler controls shall be furnished and installed by the BAS Contractor.
   2. BAS Contractor shall furnish and install the following:
      a. A manual emergency fuel burner switch located adjacent to each entrance/exit door, between 6 ft. and 7 ft. above the floor, shall be painted red and shall be labeled "Emergency Fuel Burner Switch". Wire switch to boiler control panel and hot water heater control panel so when switch is turned to "off" all fuel burners are stopped in the boiler room (typ. of 3).
      b. A heat detector shall be installed above each boiler and interfaced to the BAS to shut down gas supply to boiler room and initiate a critical alarm on high temperature.

C. Building Heating/Cooling System Control
   1. General:
      a. All controls under “C. Building Heating/Cooling System Control” shall be under one BACnet System with extra controllers when needed hooked through the SA Bus.
      b. BAS Contractor to feed a heating/cooling system enable point into the heating/cooling system from the head end consisting of 0 equals system off, 1 equals boiler enabled, and 2 equals chiller enabled to control off verses heating verses cooling. If heating/cooling system enable point is in state 0 system off all pumps and boiler shall be turned off following the delays described below. There shall also be an occupied command that will be commanded from the head end. The boiler shall be enabled at the day heating enabled setpoint of 60 degrees F. (adjustable) and the night heating enabled setpoint of 45 degrees F. (adjustable) in 1 boiler enabled mode and the chiller shall be enable at the cooling enabled setpoint of 65 degrees F (adjustable) in the 2-chiller enabled mode and be disabled in the night mode.
      c. If heating/cooling system enable point is in state 1 boiler enabled, when day/night heating is enabled, the building system circulation pump(s) BWP-1, BWP-2, or BWP-3 shall operate continuously and the boilers shall operate as described below otherwise the boilers shall be immediately commanded to OFF.
      d. If heating/cooling system enable point is in state 2 chiller enabled, when day cooling is enabled, the building system circulation pump(s) BWP-1, BWP-2, or BWP-3 shall operate continuously and the chillers shall operate as described below otherwise chillers shall be immediately commanded to OFF.
      e. Main heating or cooling plant equipment shall not start unless system water flow is established as indicated by flow switch.
      f. Boilers and chillers shall not start unless the building system circulation pump(s) is in operation as evidenced by flow switch.
      g. Provide separate boiler and chiller occupied control.
      h. See drawings and flow diagrams for additional requirements.

i. Points List - the BAS shall monitor the following points:
   1) Heating/Cooling System Enabled
   2) Day Heating Enabled Setpoint
   3) Cooling Enabled Setpoint
   4) Pump OFF Delay
   5) Heating/Cooling System Occupied
   6) Boiler Occupied (Typ. 3).
   7) Chiller Occupied (Typ. 2).
   8) Night Heating Enabled Setpoint

2. Building System Circulation Pump BWP-1, BWP-2, or BWP-3 Control:
   a. Multiple pumps serving as circulating pump and standby shall be controlled through a lead/lag/alternator sequence. All hardware and software required to provide this operation shall be furnished and installed by BAS contractor.
   b. One building system circulation pump BWP-1, BWP-2, or BWP-3 shall operate continuously at all times when heating or cooling system is enabled as described above. The other pump(s) shall be in standby control. Only one pump shall run at a time.
   c. Standby Pump(s) Control: The building system circulation pumps are staged (sequenced) through the boiler controller so that one serves as lead and other as lag pump. The lead/lag sequence alternates between respective pumps to give equal run time on each pump. Once switched to a new pump that pump must run for the minimum runtime of 1 week (adjustable) before switching to the other pump to prevent pumps from switching constantly. There should be a pump lead switch point to switch pumps from the server. Upon activation of the pump lead switch the pump shall immediately switch.
   d. Upon failure of any primary pump by alarm or loss of power, the standby pump starts. A primary pump alarm will be sent through the BAS when there is a pump call without the respective pump status and the lag pump will be running. The lead pump shall remain lead and upon repair of the lead pump it will immediately restart without need to reset the control system.
   e. The building pumps shall be alternated so as to equalize run time. The pump with the lowest operating time is lead. Once switched to a new pump, that pump must run for the minimum runtime of 168 hours (adjustable) before switching to another pump to prevent pumps from switching constantly. There should be a pump lead switch point to switch the pumps from the head end. The pumps shall switch immediately upon activation to the next pump in sequence (1 to 2, 2 to 3, 3 to 1).
   f. Indication or proof of flow for each pump and/or system shall be through positive means. Each pump shall have a differential pressure sensor in piping to indicate flow. Each line and bridge shall utilize an in-line flow proving device. Each flow proving device shall be annunciated in the BAS system.
   g. Provide two (2) differential pressure flow sensors. Locate one in each remote wing hard wired to building heating/cooling system controller. As the differential pressure changes (lowest reading to control) the DDC panel shall modulate the variable frequency drive (VFD) of the pump(s) in operation to reduce water flow and maintain the differential pressure setpoint of 8 PSI (adjustable). Only the lead pump shall run to control this pressure. The lag pump shall only come on upon failure of the lead pump. The DDC contractor shall hard wire on/off control, status, alarm, and 0 to 10-volt VDC modulation signal to each drive.
   h. The pump variable frequency drives are to be provided by the BAS contractor with a BACnet data connection. All available VFD points shall be displayed on the BAS system. The VFD’s shall be installed and power wired by the Division 16 Electrical Contractor. Control wiring is by the BAS Contractor.
   i. There shall be a building flow meter to report the gallons per minute (GPM) that the pumps are pumping. If the GPM falls below the minimum building GPM of 50 GPM (adjustable) the bypass valve shall modulate to maintain the setpoint.

j. Points List - the BAS shall monitor the following points:
   1) Building Water Pump start/stop command (hard wired to each pumps drive)
   2) Building Water Pump status (hard wired to each pumps drive)
   3) Building Water Pump Alarm (hard wired to each pumps drive)
   4) 0 to 10 Volt Building Pump Modulating Signal (hard wired to each pumps drive)
   5) Heating/Cooling System supply temperature
   6) Heating/Cooling System return temperature
   7) Building differential pressure sensors (2 required - field verify location with engineer)
   8) Differential Pressure Flow Sensor for (each pump)
   9) Primary Pump Alarm (each pump)
   10) Differential Pressure Setpoint
   11) Building Flow Meter
   12) Building Bypass Valve - Command
   13) Building Bypass Valve - Position
   14) Minimum Building GPM
   15) Pump Lead Switch
   16) Pump Minimum Runtime
   17) All available VFD points through BACnet data connection (3 required)

3. Hot Water System (Consists of three new Hot Water Boilers):
   a. On start of hot water system, chilled water system shutdown shall occur as follows:
      1) N.C. 2 position motorized cooling changeover valve shall close.
      2) Water chiller(s) shall stop.
   b. Hot water system shall start as follows:
      1) The boiler control sequence will begin when one of the building system circulation pumps has a status of ON.
      2) If in state 1 boiler enabled as described above lead and lag boiler and pumps shall start as described below. If there is no call for heat all boilers will be disabled and pumps will be turned off as described below. The lead boiler pump shall not remain on continually in state 1 boiler enabled it shall be turned off after the off delay described below
      3) N.O. 2 position motorized heating changeover valve(s) shall open.
      4) During heating mode, a minimum of one (1) boiler (lead boiler) must be online at all times with its isolation valves open.
   c. Hot water system operation:
      1) In the day mode the system supply water temperature setpoint reset shall be from the Day Low Loop setpoint of 80 degrees F. (adjustable) at the Day High OA setpoint of 60 degrees F. (adjustable) outside air to the Day High Loop setpoint of 130 degrees F. (adjustable) at Day Low OA setpoint of 0 degrees F. (adjustable) outside air temperature. In the night mode the system return water temperature setpoint reset shall be from the Night Low Loop setpoint of 80 degrees F. (adjustable) at the Night High OA setpoint of 50 degrees F. (adjustable) outside air to the Night High Loop setpoint of 120 degrees F. (adjustable) at Night Low OA setpoint of 0 degrees F. (adjustable) outside air temperature.
      2) Boilers shall not start until both heating loop isolation valves have reported an open position to the controller. Hot water boiler(s) HWB-1, 2, and 3 shall be started in sequence as required to maintain system supply water temperature setpoint. Each boiler isolation valve shall open on a call for heat from that respective boiler. Each boiler will not start until both of its boiler isolation valves have reported an open position to the controller and the building system circulation pump is proven “ON” with flow thru the boiler.
      3) If the heating loop isolation valves or boiler isolation valves status does not match its commanded value after the valve alarm delay of 2 minutes (adjustable) following being enabled, an alarm will be generated.

4) On a call for heat when the supply water temperature is below the supply water reset setpoint the lead boiler shall start its pump. After the building system circulation pump has been proven then the boiler will start. After the supply water temperature has reached the supply water reset setpoint the boiler shall turn off.
5) Once a boiler status is ON there should be a boiler signal on delay of 1 minute (adjustable) after which time the controller will send a 0 to 10-volt signal to the boiler to maintain the supply water temperature at each boiler to the system supply water temperature set point described above. If the supply water temperature out of any boiler gets above the boiler high limit of 180 degrees F. (adjustable) the controller shall cut back on the modulating signal to each respective boiler to keep it below the high limit setpoint.
6) Boilers shall be alternated so as to equalize run time. The hot water boiler with the lowest operating time is lead. Once switched to a new boiler that boiler must run for the minimum runtime of 168 hours (adjustable) before switching to the other boiler to prevent boilers from switching constantly. There should be a boiler lead switch point to switch boilers from the head end. The boilers shall switch immediately upon activation to the next boiler in sequence (1 to 2, 2 to 3, 3 to 1).
7) The lag boilers will also cycle on if the system load requires multiple boilers. If the system supply water temperature is below its setpoint by more than the lag on differential of 10 degrees F. (adjustable) the Lag boiler sequence shall start. The lag sequence shall be a lag on delay of 20 minutes (adjustable) between stages. Once the conditions above are met the following should happen. Lag # 2 shall not start until Lead #1 burner firing rate set point reaches 100% at the supply loop lag on differential of 10 degrees out of setpoint (7% firing rate at supply loop set point). If lead #1 firing rate call is at a different percent then the actual firing rate of the boiler a pid loop shall be used to increase or decrease boiler set point from 80 to 120 degrees to maintain the actual boiler firing rate to firing rate set point. Once Lag #2 is on Lead #1 shall modulate set point to keep the actual burner fire rate at 100% and Lag #2 shall modulate to maintain loop supply temperature. Once lag #2 reaches 7% Lead #1 shall start to modulate below 100% to maintain loop supply temperature. Lag #2 shall remain at 7% once started until Lead #1 is below 100% burner for the lag off delay of 5 minutes (adjustable) and shut off after this point otherwise it will remain in control. Lag # 3 shall not start until Lag #2 burner firing rate set point reaches 100% at the supply loop lag #2 on differential of 20 degrees (adjustable) out of setpoint (7% firing rate at supply loop 10 degrees out of set point). If Lag #2 firing rate call is at a different percent then the actual firing rate of the boiler a pid loop shall be used to increase or decrease boiler set point from 80 to 120 degrees to maintain the actual boiler firing rate to firing rate set point. Once Lag #3 is on Lead # 1 and Lag #2 should remain at 100% and Lag #3 shall modulate to maintain loop supply temperature. Once Lag #3 reaches 7% Lag #2 shall start to modulate below 100% to maintain loop supply temperature and Lead #1 shall remain at 100%. Lag #3 shall remain at 7% once started until Lag #2 is below 100% of burn for the lag off delay of 5 minutes (adjustable) and shut off after this point otherwise it will remain in control. Once the Lead boiler is the only boiler running the sequence will have to start from the very beginning before any more boilers are started and the loop will have to be out by the lag on differential before starting the lag boilers sequence.
8) The boilers safeties circuit will be monitored and the system will report a general alarm condition if a safety is tripped. A manual reset of the boiler safety will be required before the boiler can be restarted.
9) Boiler(s) shall operate for a minimum 15 minute (adjustable) or per manufacturer recommendations.
10) Boiler(s) shall remain OFF for a minimum 15 minute (adjustable) or per manufacturer recommendations.

11) Provide relay which will be wired into the boilers and activate when each boiler calls to be on and activate an input on the computer.

d. Points List - the BAS shall control and monitor the following for each boiler:
   1) Boiler enable/disable hard wired point (each boiler).
   2) Boiler Status hard wired point (each boiler)
   3) Boiler alarm condition hard wired point (each boiler).
   4) Boiler water supply temperature Critical alarm on high limit hard wired point (each boiler)
   5) Boiler water return temperature Critical alarm on low limit hard wired point (each boiler)
   6) Proof of water flow (each boiler).
   7) System Supply Water Temperature Day Low Loop Setpoint
   8) System Supply Water Temperature Day Low OA Setpoint
   9) System Supply Water Temperature Day High Loop Setpoint
   10) System Supply Water Temperature Day High OA Setpoint.
   11) Boiler Signal On Delay (each boiler)
   12) Boiler High Limit (each boiler)
   13) Lag on Differential
   14) Lag on Delay
   15) Minimum Runtime
   16) System Return Water Temperature Setpoint Reset
   17) Heating Loop Isolation Valves - Control (2 total)
   18) Heating Loop Isolation Valves - Position (2 total)
   19) Boiler Isolation Valve - Control (2 for each boiler)
   20) Boiler Isolation Valve - Position (2 for each boiler)
   21) Boiler Flow ON Delay
   22) Boiler Minimum ON Time
   23) Boiler Minimum OFF Time
   24) System Supply Water Temperature Night Low Loop Setpoint
   25) System Supply Water Temperature Night Low OA Setpoint
   26) System Supply Water Temperature Night High Loop Setpoint
   27) System Supply Water Temperature Night High OA Setpoint
   28) Boiler 0 to 10-volt signal hard wired point (each boiler)
   29) Lag Boiler Off Percent
   30) Boiler Run Time (3 total)
   31) Boiler Firing Rate, BAS contractor to provide 4-20 MA analog output current sensor, ACI model A/SCAT2-5 (3 total)
   32) All points available through the Boiler Manufacturer provided Modbus control system.

4. Chilled Water System (Consists of two new Chillers):
   a. On start of chilled water system, hot water system shutdown shall occur as follows:
      1) N.O. 2 position motorized heating changeover valve(s) shall close.
      2) Hot water boilers and associated boiler circulation pumps shall stop.
      3) The lead building water system pump (BWP) shall continue to run.
   b. Chilled water system shall start as follows:
      1) The chiller control sequence will begin when one of the building system circulation pumps has a status of ON.
      2) If in state 2 chiller enabled as described above N.C. 2-position motorized cooling changeover valve(s) shall open.
      3) Once the cooling changeover valves have reported back being open the chilled water pump and chiller(s) shall start.
      4) If, at any time, the chilled water temperature senses 90°F. or above, the chilled water circulation pump and the chiller shall stop, and an alarm shall sound (manual reset).

c. Chilled water system operation:
   1) Chillers shall not start until both cooling loop isolation valves have reported an open position to the controller. Chiller CH-1 and CH-2 shall be started in sequence as required to maintain system supply water temperature setpoint described in number 6 below. Each chiller isolation valve shall open on a call for cooling from that respective chiller. Each chiller will not start until both of its chiller isolation valves have reported an open position to the controller.
   2) If the cooling loop isolation valves or chiller isolation valves status does not match its commanded value after 2 minutes following being enabled, an alarm will be generated.
   3) Chillers shall be alternated so as to equalize run time. The chiller with the lowest operating time is lead. Once switched to a new chiller that chiller must run for the minimum runtime of 48 hours (adjustable) before switching to the other chiller to prevent chillers from switching constantly. There should be a chiller lead switch point to switch chillers from the head end.
   4) If flow has not been established within the chiller flow on delay of 60 seconds the next chiller shall be started.
   5) The lag chiller will also cycle on if the system load requires multiple chillers. If the system supply water temperature is below its setpoint by more than the lag on differential of 5 degrees F. (adjustable) the lag chiller sequence shall start. The lag sequence shall be a lag on delay of 10 minutes (adjustable) between stages.
   6) There shall be a chilled water reset setpoint 0 to 10 volt signal wired to the chiller which shall be reset based on outside air temperature In the day cooling mode the system supply water temperature setpoint reset shall be from the Day Cooling Low setpoint of 45 degrees F. (adjustable) at the Day Cooling Low OA setpoint of 70 degrees F. (adjustable) outside air to the Day Cooling High setpoint of 55 degrees F. (adjustable) at Day Cooling High OA setpoint of 80 degrees F. (adjustable) outside air temperature. The chiller shall be command off in the night mode.
   7) The chillers safeties circuit will be monitored and the system will report a general alarm condition if a safety is tripped.

d. Points List - the BAS shall control and monitor the following for the chiller:
   1) Chiller enable/disable hard wired point. (each chiller)
   2) Chiller 0 to 10-volt setpoint adjust hard wired point. (each chiller)
   3) Chiller Status hard wired point. (each chiller)
   4) Chiller compressor enable/disable (each compressor)
   5) Chiller compressor Status hard wired point. (each compressor)
   6) Chiller alarm condition hard wired point. (each chiller)
   7) Chilled water supply temperature Critical alarm on low limit hard wired point. (each chiller)
   8) Chilled water return temperature Critical alarm on high limit hard wired point. (each chiller)
   9) Cooling Loop Isolation Valves - Control (2 total)
   10) Cooling Loop Isolation Valves - Position (2 total)
   11) Day Cooling Low Loop setpoint
   12) Day Cooling Low OA setpoint
   13) Day Cooling High Loop setpoint
   14) Day Cooling High OA setpoint
   15) Chilled Water Reset Setpoint
   16) Chiller Isolation Valve - Control (2 for each chiller)
   17) Chiller Isolation Valve - Position (2 for each chiller)
   18) Chiller Flow ON Delay
   19) Demand Limit
   20) All points available through the Chiller Manufacturer provided BACnet control system.

5. Bypass valve control
    a. Valve shall cycle according to the owner provide schedule for valve operation based on morning warm-up. Valve shall open based on occupied schedule to the occupied bypass valve percent of 100% (adjustable).
    b. The following points shall be monitored through the BAS system:
        1) Occupied command.
        2) Bypass valve percent command.
        3) Bypass valve percent feedback.
        4) Occupied bypass valve percent.

D. ACV-1 Control Valves
1. All heat/cool isolation valves installed on this project shall be controlled through building automation. Each ACV-1 valve shall be 2-position open/closed.
    a. All ACV-1 isolation valves installed within piping to heating only equipment and hot water coil assemblies installed within air handlers shall be open when school is in heating mode and closed when in cooling mode.
    b. Controls, controllers and relays shall be mounted in hinge control boxes installed in the boiler room and/or mechanical mezzanines at an accessible height for servicing. Verify location with Architects, Engineers, and Owner.
2. All cooling and heating stop/isolation valves to be controlled with a common point from the building automation system.
3. Points List:
    a. ACV Control
    b. ACV Position (Open or Closed) for all ACV Valves

E. Domestic Hot Water System Control (Building):
1. BAS Contractor will provide a domestic boiler(s) occupied enable point for each hot water tank. Provide full port control valve of each tank inlet size to the Plumber to be installed in the water inlet of each tank. Valve shall be on/off spring opened (Rubinetterie Bresciane Series 25ON LF with Belimo Actuator). Valve shall be open all the time except in the summer months 1 tank will only be occupied to run the Main Office (when the West tank is occupied the East tank valve will be shut, when the East tank is occupied the West tank valve will be shut).
2. BAS Contractor shall provide maximum of twelve (12) well mounted temperature sensors to the Plumbing Contractor to be installed in the main supply pipe, four (4) separate return pipe zones plus the main return pipe, and 2 tank temperatures of the hot water system.
3. BAS will start/stop the building hot water tank based on the hot water supply max setpoint of 110 degrees F. (adjustable). Under normal conditions the tank will start/stop itself on its internal controls
4. BAS will control start/stop of the building domestic hot water recirculation pumps based on a separate domestic building pump schedule and provide pump status.
5. Controls, controllers, and relays shall be mounted in hinge control boxes installed in Boiler Room 115 at an accessible height for servicing. Verify location with Architects, Engineers, and Owner.
6. See Plumbing Detail Sheet P5.03 for additional requirements.
7. Points List:
    a. Occupied West Hot Water Tank
    b. Occupied East Hot Water Tank
    c. West Hot Water Tank Command
    d. East Hot Water Tank Command.
    e. West Hot Water Tank Temperature
    f. East Hot Water Tank Temperature
    g. Hot Water Supply Temperature
    h. Hot Water Return Temperature
    i. Area D Return Temperature (Typ. 2)
    j. Area A & B Return Temperature (Typ. 2)
    k. Occupied Area D Return Pump (Typ. 2)

l. Area D Return Pump Command (Typ. 2)
m. Area D Return Pump Status (Typ. 2)
n. Occupied Area A & B Return Pump (Typ. 2)
o. Area A & B Return Pump Command (Typ. 2)
p. Area A & B Return Pump Status (Typ. 2)
q. East Tank Valve
r. West Tank Valve

F. Domestic Hot Water System Control (Gym):
1. BAS Contractor will provide a domestic boiler occupied enable point for hot water tank.
2. BAS Contractor shall provide a minimum of four (4) well mounted temperature sensors to the Plumbing Contractor to be installed in the main cold-water supply pipe, the main hot water supply pipe, the main hot water return pipe, the hot water return from the back wing pump, the hot water return from the front wing pump, and 1 tank temperature of the hot water system.
3. BAS will start/stop the building hot water tank based on the hot water supply max setpoint of 110 degrees F. (adjustable). Under normal conditions the tank will start/stop itself on its internal controls
4. BAS will control start/stop of the building domestic hot water recirculation pump based on a separate domestic building pump schedule and provide pump status.
5. Controls, controllers and relays shall be mounted in hinge control boxes installed in Gym Deck Machinery Space 100GD at an accessible height for servicing. Verify location with Architects, Engineers and Owner.
6. See Plumbing Detail Sheet P5.03 for additional requirements.
7. Points List:
   a. Occupied Hot Water Tank
   b. Hot Water Tank Command
   c. Hot Water Tank Temperature
   d. Cold-Water Supply Temperature
   e. Hot Water Supply Temperature
   f. Main Hot Water Return Temperature
   g. Occupied Return Pump
   h. Return Pump Command
   i. Return Pump Status

G. Fin Tube Radiation and/or Convector Control
1. General:
   a. If the Boiler/Chiller Enable point is in state 1 Boiler mode the radiation/convector should be allowed to run otherwise it should remain off.
   b. When hot water supply temperature is 90 degrees F. or greater as determined by BAS, the finned tube radiation and/or convector shall be permitted to run.
   c. Sequence with associated air handling unit, VAV box and/or vertical unit ventilator.
   d. Controls, controllers, and relays shall be mounted in hinge control boxes installed in the boiler room, and/or mechanical mezzanines at an accessible height for servicing. Verify location with Architects, Engineers, and Owner. The only exception to this will be radiators which are in a VAV space, then they should be controlled by their VAV controller.
2. Occupied Cycle Heating:
   a. In the Occupied mode, the finned tube radiation and/or convector shall cycle to maintain space temperature. When the room temperature falls below the Occupied Heating On Setpoint of 71 degrees F. (adjustable) the valve shall be commanded to 100%. Once the space temperature reaches the Occupied Heating Off setpoint of 72 degrees F. (adjustable) the valve shall go to its min position as described below and modulate below minimum to zero if room gets 1 degree over set point.

3. Unoccupied Cycle Heating Mode:
    a. In the unoccupied mode, the finned tube radiation and/or convector shall cycle to maintain night setback temperature. When the room temperature falls below the Unoccupied Heating On Setpoint of 58 degrees F. (adjustable) the valve shall be commanded to 100% once the space temperature reaches the Unoccupied Heating Off setpoint of 60 degrees F. (adjustable) the valve shall go to its min position as described below.
    b. The heating valve shall modulate to its minimum. The minimum will be Valve Min Percent of 30% (adjustable) when the outside air temperature falls below the Valve Min OA of 35 degrees F. (adjustable) above this outside air temperature the valve shall remain closed.
    c. When the unit is unoccupied there shall be a Valve Exercise Enable point, which can be cycled from the head end computer. As long as the unit is unoccupied the valve exercise shall occur regardless whether it is in summer or winter mode. The valve shall be cycled to 100% for the valve exercise time of 3 minutes (adjustable), then cycled to 0% using the same valve exercise time stated above, then released to the percent it is calling for.
4. Use Control Valve to provide local chilled water isolation and control if not provided by ACV shown on plans (when chiller is on valve is to be commanded to 0).
5. Sequence control valve on fin tube radiation open first when sequenced with another piece of equipment (i.e., AHU, VUV, VAV, etc.).
6. Provide space temperature and valve position for each fin tube radiation and/or convector.
7. There shall be an occupied override button to return the unit to occupied. The occupied override time shall be 30 minutes adjustable.
8. The following points shall be monitored through the BAS system:
    a. Room Temperature.
    b. Hot Water Valve Command (furnished and wired by the BAS contractor).
    c. Hot Water Valve position.
    d. Occupied/Unoccupied Mode.
    e. Occupied Heating On Setpoint
    f. Occupied Heating Off Setpoint
    g. Unoccupied Heating On Setpoint
    h. Unoccupied Heating Off Setpoint
    i. Valve Exercise Enable
    j. Valve Exercise Time
    k. Occupied Override Time
    l. Boiler/Chiller Enable

H. Single Zone Variable Air Volume Air Handling Unit Control
1. General
    a. Control electronically with dedicated stand-alone HVAC controller.
    b. Match current building schedules.
    c. All set points will be adjustable through the BAS, at the operator workstation, through a computer with internet service and through a smart phone.
    d. Provide damper operators (Belimo).
    e. Controls, controllers, and relays shall be mounted in hinge control boxes installed in the boiler room and/or mechanical mezzanines at an accessible height for servicing. Verify location with Architects, Engineers, and Owner.
    f. BAS Contractor to feed a system enable point into the AHU Controller consisting of 0 equals system off, 1 equals boiler enabled, and 2 equals chiller enabled to control heating/cooling valve. If in State 0 the controller shall only run the outside air damper as described below.

2. Occupied Cycle Heating:
   a. The current (active) heat setpoint shall be the occupied heating setpoint of 72 degrees F. (adjustable) plus or minus 1-degree F. from the slide dial setpoint adjust.
   b. If in State 1 Boiler Enabled the fan will operate continuously. Controller to cycle fan through infinite speed control range as required to meet room temperature setpoint. On a call for heat, the heating valve shall modulate under control of the space temperature sensor.
   c. A low temperature freeze protection thermostat located on the discharge of the water coil, shall upon sensing a drop in temperature below its setpoint, 38 degrees F. (adjustable), spring open the control valve, shut down the unit fan and spring close the fresh air damper. This control must be auto reset.
   d. Once the space temperature setpoint is reached, the outdoor air damper will modulate open above minimum setting to keep space from overheating using the current (active) cooling setpoint described in “Occupied Cycle Cooling”.
   e. The discharge air low limit (DALL) reset shall be from the Low setpoint of 50 degrees F. (adjustable) at the High OA setpoint of 60 degrees F. (adjustable) outside air to the High setpoint of 65 degrees F. (adjustable) at Low OA setpoint of 35 degrees F. (adjustable) outside air temperature.
   f. If the discharge air temperature drops below the DALL the outdoor air damper will modulate to minimum and the 2-way valve shall modulate to provide required heat to maintain the discharge temperature.
   g. If the mixed air temperature drops below the mixed air low limit of 35 degrees F. (adjustable), the outdoor air damper will modulate to 0% and the 2-way valve shall modulate to its minimum position (adjustable) as described in “Unoccupied Cycle” and modulate past minimum to maintain the discharge air temperature. The freeze protection shall start and remain on until mixed air temperature rises.
3. Occupied Cycle Cooling:
   a. The current (active) cool setpoint shall be the occupied cooling setpoint of 74 degrees F. (adjustable) plus or minus 1-degree F. from the slide dial setpoint adjust.
   b. If in State 2 Chiller Enabled, the fan will operate continuously. Controller to cycle fan through infinite speed control range as required to meet room temperature setpoint the cooling valve shall modulate to maintain space temperature after the outdoor air damper modulates through the Economizer Control sequence as stated below. The cooling valve shall modulate closed to maintain the discharge air low limit reset as described in Occupied Cycle Heating sequence as stated above.
   c. Economizer Control: The BAS shall provide outside air temperature to the controller. If chilled water is available and the outdoor air temperature is over the Economizer Enable Setpoint of 68 degrees F. (adjustable) dry bulb, then the outdoor air damper will return to its minimum position. If chilled water is not available and the outdoor air temperature is higher than the space temperature, then the outdoor air damper will return to its minimum position. If either of these conditions don’t exist the outdoor air damper shall modulate to maintain the space temperature and the discharge air low limit reset as described in Occupied Cycle Heating sequence as above
4. Morning Warm Up Cycle:
   a. The outdoor air damper will remain closed, the 2-way heating valve shall open to full heat and the unit will run continuously in its highest speed. Once the space temperature setpoint is reached, the outdoor air damper, heating valve and unit will control as called for in "Occupied Cycle Heating".
   b. There shall be a warm up off delay of 10 minutes (adjustable) before outside air damper is allowed to open.

5. Unoccupied Cycle:
   a. In the unoccupied winter mode when boiler is enabled, the air handling unit shall cycle to maintain night setback temperature. When the room temperature falls below the Unoccupied Heating On Setpoint of 58 degrees F. (adjustable) the valve shall be commanded to 100% and the fan shall be commanded to its highest speed. Once the space temperature reaches the Unoccupied Heating Off setpoint of 60 degrees F. (adjustable) the valve shall go to its min. position as described below and the fan shall be commanded to OFF. If boiler is not enabled fan shall remain off.
   b. The outdoor air damper will remain closed and the heating valve shall modulate to its minimum. The minimum will be Valve Min Percent of 30% (adjustable) when the outside air temperature falls below the Valve Min OA of 35 degrees F. (adjustable) above this outside air temperature the valve shall remain closed.
   c. If mixed air or discharge air temperature falls below the Unoccupied Low Limit On setpoint of 40 degrees F. (adjustable) the heating valve shall modulate to 100% until all sensors are above the Unoccupied Low Limit Off setpoint of 50 degrees F. (adjustable).
   d. Heating valve remains full open and the fan shall be commanded to off on any freeze stat activation.
   e. There will be no nighttime cooling.
   f. There shall be an occupied override button to return the unit to occupied. The occupied override time shall be 30 minutes adjustable.
   g. When the unit is unoccupied there shall be a Valve Exercise Enable point, which can be cycled from the head end computer. As long as the unit is unoccupied the valve exercise shall occur regardless whether it is in summer or winter mode. The valve shall be cycled to 100% for the valve exercise time of 3 minutes (adjustable), then cycled to 0% using the same valve exercise time stated above, then released to the percent it is calling for.
6. Outdoor Air Damper Control:
   a. The BAS Contractor shall furnish and install a room mounted CO2 sensor and provide all programming for demand control ventilation operation, CO2 setpoints and damper position setpoints.
   b. When the room CO2 is below the Low CO2 of 750 PPM (adjustable) the damper shall be closed unless in economizer mode.
   c. When the room CO2 is above the High CO2 of 1000 PPM (adjustable) the damper shall open to the Outdoor Air Damper – Minimum Position Setpoint of 10% (adjustable) setpoint unless in economizer mode (this shall be a modulated reset open with 750 being 0 and 1,000 being at the Min Position Set Point).
   d. When free cooling is available the outdoor air damper shall control to maintain the discharge air low limit reset as described under the “Occupied Cycle Heating” or “Occupied Cycle Cooling” and allow for chilled water to supplement cooling when available.
   e. The BAS Contractor to control associated return/exhaust fan(s) VFD. All return VFD’s shall follow the supply VFD and all exhaust VFD’s shall follow the OA damper setpoint.
7. Energy Wheel Control (if equipped):
   a. When the CO2 is above the High CO2 of the 1000 ppm (adjustable) the Heat Wheel will turn on the dampers will be indexed to provide full flow through the wheel. When the room CO2 is above the Low CO2 of 750 ppm (adjustable) by the Low CO2 Differential of 50 ppm (adjustable) the heat wheel will turn off and the dampers will be indexed to provide full return air to the supply blower.
   b. If the heat recovery exhaust air temperature falls below the exhaust air low limit set point of 32 degrees F. (adjustable) the dampers will modulate to the bypass position in an attempt to not build frost on the wheel.
   c. In the Night Mode the Heat Wheel shall be turned off and the dampers shall be indexed so full return air enters into the supply blower.

   d. If in Economizer Control the Heat Wheel shall be turned off and the dampers shall be indexed to provide free cooling to the space otherwise the bypass damper shall remain closed.
   e. Provide status of the Heat Wheel and the Exhaust Fan and feedback position on all dampers associated with the Heat Wheel.
   f. Interlock exhaust discharge damper with unit/wheel operation.
8. Smoke/Fire Fan Shutdown:
   a. On a signal from the addressable relay, provided by the Electrical Contractor, the associated supply and return/exhaust fan shall be shut down. See electrical plans for quantity and locations. BAS to provide wire to addressable relay for fan shut-down.
9. Static High Limit:
   a. Supply and return/exhaust fan will shut down if the discharge air static pressure exceeds 3” WC (adjustable) and restart once pressure drops.
10. Failure Modes:
   a. Fan Failure: If any fan fails to operate an alarm shall be annunciated. Dampers and control valves shall stay in control and the unit shall continue to run.
   b. Sensor Failure: Upon the failure of an analog sensor, associated dampers and control valves shall remain in control as long as the sensor that failed doesn’t affect the operation of the unit. If the failed sensor affects the operation associated dampers and control valves shall be indexed to their unoccupied positions and alarm shall be annunciated and the unit shall continue to run.
   c. Power Failure:
      1) Fans: Upon restoration of power, the supply fan and return/exhaust fan shall start after an adjustable delay to provide a staggered start of all building loads.
      2) Dampers: Dampers shall be provided with Belimo spring return actuators to fail to their “System Off” positions.
      3) Valves: Heating valves shall be provided with Belimo spring return actuator to fail open to the coil.
11. The following points shall be monitored through the BAS system:
   a. Blower Command hard wired point
   b. Blower Status hard wired point
   c. Blower 0 to 10 VDC Speed Control hard wired point
   d. Discharge Air Temperature
   e. Mixed Air Temperature
   f. Outdoor Air Temperature (global software point).
   g. Room Temperature
   h. Chilled & Hot water Valve - Command (furnished and wired by the BAS contractor).
   i. Chilled & Hot water Valve - Position.
   j. Outdoor/Return/Exhaust Air Damper – Command (if there are 2 dampers both commands shall be provided).
   k. Outdoor/Return/Exhaust Air Damper – Position (if there are 2 dampers all positions shall be provided)
   l. Outdoor Air Damper – Minimum Position Setpoint.
   m. Unoccupied Low Limit On
   n. Unoccupied Low Limit Off
   o. Occupied Cooling Setpoint.
   p. Current (Active) Cool Setpoint.
   q. Occupied Heating Setpoint
   r. Current (Active) Heat Setpoint.
   s. Unoccupied Heating On Setpoint
   t. Unoccupied Heating Off Setpoint
   u. Duct CO2 Sensor (furnished, installed and programmed for Demand Control Ventilation by BAS).
   v. Setpoint Adjustment (Plus/minus 1 degrees F.).
   w. Occupied/Unoccupied Mode.

x. Low Limit Safety.
y. Discharge Air Low Limit
z. Mixed Air Low Limit
aa. Boiler/Chiller Enabled
bb. Econ Enable Setpoint
cc. Valve Min Percent
dd. Valve Min OA
ee. Low CO2
ff. High CO2
gg. Occupied Override Time
hh. DALL Low Setpoint
ii. DALL Low OA Setpoint
jj. DALL High Setpoint
kk. DALL High OA Setpoint
ll. Smoke detector status, critical alarm
mm. Hot/Chilled Water Temperature inlet and out of coil
nn. Supply ductwork pressure and Setpoint
oo. Fan Status (supply and return/exhaust)
pp. Exhaust Fan Command hard wired point
qq. Exhaust Fan Status hard wired point
rr. Exhaust Fan 0 to 10 VDC Speed Control hard wired point
ss. All available Supply Fan and Exhaust Fans VFD points through BACnet data connection (requirements change per unit)
tt. Valve Exercise Enable
uu. Valve Exercise Time
vv. Warm Off Delay
ww. Low CO2 Differential
xx. Heat Wheel Damper - Command (If multiple dampers all commands shall be provided)
yy. Heat Wheel Damper - Position (if multiple dampers all commands shall be provided)
zz. Heat Wheel Motor Command
aaa. Heat Wheel Motor Status
bbb. Exhaust Air Temperature
ccc. Exhaust Air Low Limit Setpoint
ddd. Return Air Temperature
eee. Min Position Setpoint
fff. CO2 level

I. Variable Air Volume Air Handling Unit Control
   1. General
      a. Control electronically with dedicated stand-alone HVAC controller.
      b. Match current building schedules.
      c. All set points will be adjustable through the BAS, at the operator workstation, through a computer with internet service and through a smart phone.
      d. Provide damper operators (Belimo).
      e. Controls, controllers, and relays shall be mounted in hinge control boxes installed in the boiler room and/or mechanical mezzanines at an accessible height for servicing. Verify location with Architects, Engineers, and Owner.
      f. BAS Contractor to feed a system enable point into the AHU Controller consisting of 0 equals system off, 1 equals boiler enabled, and 2 equals chiller enabled to control heating/cooling valve. If in State 0 the controller shall only run the outside air damper as described below.

2. Occupied Cycle Heating/Cooling:
   a. The current (active) discharge air setpoint shall be the discharge air low limit (DALL) reset described below.
   b. BAS Contractor to feed a system enable point into the AHU Controller consisting of 0 equals system off, 1 equals boiler enabled, and 2 equals chiller enabled to control hot cold deck verses bypass deck.
      1) If in boiler enabled, the fan will operate continuously. Controller to vary speed of supply fan via VFD as required to maintain duct static pressure of 1” WC (adjustable). The return fan shall track the supply fan exactly. The outdoor air damper will be opened (subject to the mixed air low limit thermostat) to a minimum position as described under outside air damper control and modulate past minimum as described in Economizer Control. On a call for heat, the heating valve shall modulate under control of the discharge air sensor.
      2) If in chiller enabled, the fan will operate continuously. Controller to vary speed of supply fan via VFD as required to maintain duct static pressure of 1” WC (adjustable). The return/exhaust fan shall track the supply fan exactly. The outdoor air damper will be opened (subject to the mixed air low limit thermostat) to a minimum position as described under outside air damper control and modulate past minimum as described in Economizer Control. On a call for cooling, the cooling valve shall modulate under control of the discharge air sensor. If the chiller is not enabled cooling valve shall modulate to 0 and the DX unit shall control to maintain the discharge setpoint.
   c. A low temperature freeze protection thermostat located on the discharge of the water coil, shall upon sensing a drop in temperature below its setpoint, 38 degrees F. (adjustable), spring open the control valve, shut down the fans and spring close the fresh air damper. This control must be auto reset.
   d. The discharge air and duct static pressure are to be reset based on zone demand. All VAV box zone demands shall be inputted to the air handler controller. The discharge air low limit (DALL) reset shall be from the cooling low setpoint of 55 degrees F. (adjustable) at the cooling high zone demand setpoint of 100% (adjustable) to the low cooling setpoint of 73 degrees F. (adjustable) at the cooling low zone demand setpoint of 0% (adjustable). If all VAV controllers are below 0% the highest negative zone demand shall be used to input heat into the spaces (i.e. Minus 10 verse Minus 20 - Minus 10 to be used). The discharge air low limit (DALL) reset shall be from the heating high setpoint of 90 degrees F. (adjustable) at the heating low zone demand setpoint of minus 100% (adjustable) to the low heating setpoint of 73 degrees F. (adjustable) at the heating high zone demand setpoint of 0% (adjustable).
   e. The minimum discharge air low limit (MDALL) reset shall be from the Low setpoint of 55 degrees F. (adjustable) at the Low OA setpoint of 60 degrees F. (adjustable) outside air to the High setpoint of 65 degrees F. (adjustable) at High OA setpoint of 35 degrees F. (adjustable) outside air temperature. This shall be the lowest the discharge air can go this shall not be used to reset the discharge setpoint b. above shall be used for the reset and this will just limit the discharge setpoint in cooler temperatures.
   f. If the discharge air temperature drops below the DALL the outdoor air damper will modulate to minimum and the 2-way valve shall modulate to provide required heat to maintain the discharge temperature.
   g. If the mixed air temperature drops below the mixed air low limit of 40 degrees F. (adjustable), the outdoor air damper will modulate to 0% and the 2-way valve shall modulate to its minimum position (adjustable) as described in “Unoccupied Cycle” and modulate past minimum to maintain the discharge air temperature. The freeze protection shall start and remain on until mixed air temperature rises.

h. Economizer Control: The BAS shall provide outside air temperature to the controller. If chilled water is available and the outdoor air temperature is over the Economizer Enable Setpoint of 68 degrees F. (adjustable) dry bulb, then the outdoor air damper will return to its minimum position. If chilled water is not available and the outdoor air temperature is higher than the space temperature, then the outdoor air damper will return to its minimum position. If both of these conditions don't exist the outdoor air damper shall modulate to maintain the space temperature and the discharge air low limit reset as described in Occupied Cycle Heating sequence as above. BAS contractor to control associated return and/or exhaust fan VFD to maintain a positive space pressure of 0.05" WC (adjustable).

i. The air handling unit shall operate with chilled water as stated above when chiller is in operation. When chiller is not operating, AHU will get its cooling via a unit mounted direct expansion (DX) cooling coil and remote condensing unit. The air handling unit will continue to operate as stated in the sequence above by cycling the remote condensing unit in lieu of modulating the chilled water valve. Condensing unit to have hot gas bypass. The air handling unit shall monitor the discharge air leaving the DX coil to keep from icing the DX coil and freezing the chilled/hot water coil. If the discharge temperature off the DX coil drops to below 40 degrees F. de-energize the condensing unit and raise the fan speed to 100%. The chilled/hot water coil will be locked out when the condensing unit is in operation. The remote condensing unit is to be locked out when the chiller is in operation.

3. Morning Warm Up Cycle:
   a. The outdoor air damper will remain closed, the 2-way heating valve shall open to full heat, the unit will run continuously in its highest speed. Once the space temperature setpoint is reached, the outdoor air damper, heating valve and unit will control as called for in "Occupied Cycle Heating/Cooling".
   b. There shall be a warm up off delay of 10 minutes (adjustable) before outside air damper is allowed to open.
4. Unoccupied Cycle:
   a. The air handler shall remain OFF and the existing finned tube radiation shall cycle ON/OFF to maintain Unoccupied Heating Setpoint as stated in existing Fin Tube Radiation Control
   b. If the existing finned tube cannot maintain the unoccupied setpoint, the air handling unit shall cycle to maintain night setback temperature. When the lowest room temperature falls below the Unoccupied Heating On Setpoint of 56 degrees F. (adjustable) the valve shall be commanded to 100% and the supply and return fans shall be energized as stated above. Once the space temperature reaches the Unoccupied Heating Off setpoint of 58 degrees F. (adjustable) the valve shall go to its min. position as described below and the fans shall be commanded to OFF. If boiler is not enabled fan shall remain off
   c. The outdoor air damper will remain closed and the heating valve shall modulate to its minimum. The minimum will be Valve Min Percent of 30% (adjustable) when the outside air temperature falls below the Valve Min OA of 35 degrees F. (adjustable) above this outside air temperature the valve shall remain closed.
   d. If mixed air or discharge air temperature falls below the Unoccupied Low Limit On setpoint of 35 degrees F. (adjustable) the heating valve shall modulate to 100% until all sensors are above the Unoccupied Low Limit Off setpoint of 50 degrees F. (adjustable).
   e. Heating valve remains full open and the fans shall be commanded to off on any freeze stat activation.
   f. There will be no nighttime cooling.
   g. There shall be an occupied override button to return the unit to occupied. The occupied override time shall be 30 minutes adjustable.

h. When the unit is unoccupied there shall be a Valve Exercise Enable point, which can be cycled from the head end computer. As long as the unit is unoccupied the valve exercise shall occur regardless whether it is in summer or winter mode. The valve shall be cycled to 100% for the valve exercise time of 3 minutes (adjustable), then cycled to 0% using the same valve exercise time stated above, then released to the percent it is calling for.

5. Outdoor Air Damper Control:
   a. The BAS Contractor shall furnish and install a room mounted CO2 sensor and provide all programming for demand control ventilation operation, CO2 setpoints and damper position setpoints (every VAV box shall have a room mounted CO2 sensor and the highest CO2 sensor shall be used for this reset).
   b. When the room CO2 is below the Low CO2 of 750 PPM (adjustable) the damper shall be closed unless in economizer mode.
   c. When the room CO2 is above the High CO2 of 1000 PPM (adjustable) the damper shall open to the Outdoor Air Damper – Minimum Position Setpoint of 10% (adjustable) setpoint unless in economizer mode (this shall be a modulated reset open with 750 being 0 and 1,000 being at the Min Position Set Point).
   d. When free cooling is available the outdoor air damper shall control to maintain the discharge air low limit reset as described under the “Occupied Cycle Heating” or “Occupied Cycle Cooling” and allow for chilled water to supplement cooling when available.
   e. The BAS Contractor to control associated return/exhaust fan(s) VFD to maintain positive space pressure set point of 0.05” WC (adjustable).
6. Smoke/Fire Fan Shutdown:
   a. On a signal from the addressable relay, provided by the Electrical Contractor, the associated supply and return/exhaust fan shall be shut down. See electrical plans for quantity and locations. BAS to provide relay and wire to duct some detectors for fan shut-down.
7. Static High Limit:
   a. Supply and return/exhaust fan will shut down if the discharge air static pressure exceeds 3” WC (adjustable) and restart once pressure drops.
8. Failure Modes:
   a. Fan Failure: If any fan fails to operate an alarm shall be annunciated. Dampers and control valves shall stay in control and the unit shall continue to run.
   b. Sensor Failure: Upon the failure of an analog sensor, associated dampers and control valves shall remain in control as long as the sensor that failed doesn’t affect the operation of the unit. If the failed sensor affects the operation associated dampers and control valves shall be indexed to their unoccupied positions and alarm shall be annunciated and the unit shall continue to run.
   c. Power Failure:
      1) Fans: Upon restoration of power, the supply fan and return/exhaust fan shall start after an adjustable delay to provide a staggered start of all building loads.
      2) Dampers: Dampers shall be provided with Belimo spring return actuators to fail to their “System Off” positions.
      3) Valves: Heating valves shall be provided with Belimo spring return actuator to fail open to the coil.
9. The following points shall be monitored through the BAS system:
   a. Blower Command hard wired point.
   b. Blower Status hard wired point.
   c. Blower 0 to 10 VDC Speed Control hard wired point.
   d. Discharge Air Temperature
   e. Mixed Air Temperature
   f. Outdoor Air Temperature (global software point).
   g. Water in Temperature (global software point).
   h. Chilled & Hot water Valve - Command (furnished and wired by the BAS contractor).

i. Chilled & Hot water Valve - Position.
j. Outdoor/Return/Exhaust Air Damper – Command (if there are 2 dampers both commands shall be provided)
k. Outdoor/Return/Exhaust Air Damper – Position (if there are 2 dampers both positions shall be provided)
l. Outdoor Air Damper – Minimum Position Setpoint.
m. Unoccupied Low Limit On
n. Unoccupied Low Limit Off
o. Current (Active) Discharge Setpoint.
p. Unoccupied Heating On Setpoint
q. Unoccupied Heating Off Setpoint
r. Duct CO2 Sensor (furnished, installed and programmed for Demand Control Ventilation by BAS).
s. Setpoint Adjustment (Plus/minus 1 degrees F.).
t. Occupied/Unoccupied Mode.
u. Low Limit Safety.
v. Discharge Air Low Limit
w. Mixed Air Low Limit
x. Boiler/Chiller Enabled
y. Econ Enable Setpoint
z. Valve Min Percent
aa. Valve Min OA
bb. Low CO2
cc. High CO2
dd. Occupied Override Time
ee. DALL Low Cooling Setpoint
ff. DALL Cooling High Zone Demand Setpoint
gg. DALL High Cooling Setpoint
hh. DALL Cooling Low Zone Demand Setpoint
ii. DALL High Heating Setpoint
jj. DALL Heating Low Zone Demand Setpoint
kk. DALL Low Heating Setpoint
ll. DALL Heating High Zone Demand Setpoint
mm. MDALL Low Setpoint
nn. MDALL Low OA Setpoint
oo. MDALL High Setpoint
pp. MDALL High OA Setpoint
qq. Smoke detector status, critical alarm
rr. Hot/Chilled Water Temperature inlet and out of coil
ss. Supply Ductwork Pressure and Setpoint
tt. Fan Status (supply and return/exhaust)
uu. Space Pressure and Positive Space Pressure Setpoint
vv. Return/Exhaust Fan Command hard wired point
ww. Return/Exhaust Fan Status hard wired point
xx. Return/Exhaust Fan 0 to 10 VDC Speed Control hard wired point
yy. All available Supply Fan and Exhaust Fans VFD points through SA Bus or BACnet data connection (requirements change per unit)
zz. Valve Exercise Enable
aaa. Valve Exercise Time
bbb. Warm Up Off Delay
ccc. Return Air Temperature

J. Variable Air Volume Box Control with Hot Water Coil Control
1. General:
a. When hot water supply temperature is 90 degrees F. or greater as determined by BAS, the hot water coil shall be permitted to run.

b. Sequence with associated radiator (provide one controller to control radiation and box as a single unit).
c. The VAV terminal units shall be individually controlled by a DDC controller per terminal unit. The DDC controller with integral damper motor and transducer shall be furnished and installed by the BAS contractor in the field. A step-down power transformer shall be furnished and installed by the BAS contractor
d. Discharge Air Temperature Sensor: A discharge air temp sensor is to be provided on each box for monitoring purposes.
e. Each box shall have a separate Occupied Command so we can return the box at any time to occupied for heating only of the space when the AHU is not running or individual control of each box so all boxes will not have to run just because the AHU is on.

2. Occupied Cycle:
   a. The current (active) heat setpoint shall be the occupied heating setpoint of 72 degrees F. (adjustable) plus or minus 1-degree F. from the slide dial setpoint adjust. The current (active) cool setpoint shall be the occupied cooling setpoint of 74 degrees F. (adjustable) plus or minus 1-degree F. from the slide dial setpoint adjust. There should be a heating differential setpoint of 2 degrees (adjustable) and a cooling differential setpoint of 2 degrees (adjustable).
   b. When the zone temperature is at the current (active) heat setpoint the zone heat demand shall be at 0%. When the zone temperature is below the heat setpoint by the heating differential setpoint the zone heat demand shall be a -100%. When the zone temperature is at the current (active) cool setpoint the zone cool demand shall be at 0%. When the zone temperature is above the cool setpoint by the cooling differential setpoint the zone cool demand shall be a 100%. This percentage shall be the VAV box zone demand.
   c. When the zone temperature is between the current (active) heating and cooling setpoints (inside of the bias), the primary air damper will be at the minimum cfm and the reheat valve will be fully closed. On a rise in zone temperature above the current (active) cooling setpoint, the primary air damper will increase the cfm and the reheat valve remains fully closed. The maximum air damper position shall not exceed the zone cool demand percent. There shall be a max air disabled point which can be activated from the head end to disable this feature. On a drop in zone temperature below the current (active) heating setpoint, the reheat valve modulates open and the damper is controlled to provide a minimum cfm and modulate past minimum to max cfm if temperature continues to fall. The maximum air damper position shall not exceed the absolute value of the zone heat demand percent. There shall be a max air disabled point which can be activated from the head end to disable this feature.
   d. The BAS Contractor shall furnish and install a wall mounted CO2 sensor in the - - rooms for each VAV box and provide all programming for demand control ventilation operation, CO2 setpoints and damper position setpoints. When the room CO2 is below the Low CO2 of 750 PPM (adjustable) the damper shall in control. When the room CO2 is above the High CO2 of 1000 PPM (adjustable) the damper shall open its damper to Minimum Position Setpoint of 10% (adjustable) (this shall be a modulated reset open with 750 being 0 and 1,000 being at the Min Position Set Point). The damper will modulate past minimum when necessary, as stated above.

3. Unoccupied Cycle:
   a. In the unoccupied mode, when the room temperature falls below the Unoccupied Heating ON Setpoint of 58 degrees F. (adjustable) the valve and damper shall be commanded to 100%, once the space temperature reaches the Unoccupied Heating Off setpoint of 60 degrees F. (adjustable) the valve and damper shall go to its min position as described below and the fan shall be commanded to OFF.

b. The heating valve shall modulate to its minimum. The minimum will be Valve Min Percent of 30% (adjustable) when the outside air temperature falls below the Valve Min OA of 35 degrees F. (adjustable) above this outside air temperature the valve shall remain closed.
c. There will be no nighttime cooling.
d. There shall be an occupied override button to return the unit to occupied. This shall turn on the radiator for heating purposes only. The occupied override time shall be 30 minutes adjustable.
e. When the unit is unoccupied there shall be a Valve Exercise Enable point which can be cycled from the head end computer. As long as the unit is unoccupied the valve exercise shall occur regardless whether it is in summer or winter mode. The valve shall be cycled to 100% for the valve exercise time of 3 minutes (adjustable), then cycled to 0% using the same valve exercise time stated above, then released to the percent it is calling for.

4. Safeties and Alarms:
   a. An alarm shall be noted in the event of a low and/or high temperature limit in the zone sensor.
5. Use Control Valve to provide local chilled water isolation and control if not provided by ACV shown on plans (when chiller is on valve is to be commanded to 0).
6. Points List:
   a. Discharge Air Temperature
   b. Space Temperature
   c. Occupied Heating Setpoint
   d. Occupied Cooling Setpoint
   e. Reheat Valve – Command
   f. Reheat Valve – Position
   g. Occupied Mode
   h. Unoccupied Heating ON
   i. Unoccupied Heating OFF
   j. Valve Min,
   k. Valve Min, OA
   l. Active Cooling Setpoint
   m. Active Heating Setpoint
   n. Valve Exercise Enable
   o. Valve Exercise Time
   p. Heating Differential Setpoint
   q. Cooling Differential Setpoint
   r. Max Air Disabled
   s. Low CO2
   t. High CO2
   u. Min Position Setpoint
   v. CO2 Level
7. See Section 15930 for additional requirements.

K. Fire Shut Down for Air Supply Unit Over 2000 CFM
1. The Electrical Contractor shall furnish and install smoke and/or heat detectors in air supply system over 2000 CFM. An addressable fire alarm relay shall be furnished and installed by the Electrical Contractor and mounted by the control box for each system. BAS Contractor shall pick up signal from relay and provide a program to stop all supply and return/exhaust fans interlocked with the system sensing fire or smoke. DDC program shall also show fire in unit alarm at time of shut down.
2. Air supply units 15,000 CFM and over shall require smoke and/or heat detectors on both supply and return.
3. Points List:
   a. Fire Shut Down Status

L. Hot Water Coil (Duct Mounted) and Motorized Damper Control
   1. General:
      a. When hot water supply temperature is 90 degrees F. or greater as determined by BAS, the hot water coil shall be permitted to run.
      b. The hot water coil valve and motorized air damper shall be individually controlled by a DDC controller. The DDC controller(s) and damper motor(s) shall be furnished and installed by the BAS contractor in the field. A step-down power transformer shall be furnished and installed by the BAS contractor if required.
      c. Discharge Air Temperature Sensor: A discharge air temp sensor is to be provided on hot water coil for monitoring purposes.
      d. Each coil/damper shall have a separate Occupied/Unoccupied Command with individual control of each coil/damper so all coil/dampers will not have to run just because the VUV is on.
      e. The motorized dampers shall not be allowed to close more than the minimum position of 25% (adj.).
      f. Controls, controllers, and relays shall be mounted in hinge control boxes installed in the boiler room and/or mechanical mezzanines. Verify location with Architects, Engineers, and Owner.
   2. Occupied Cycle:
      a. The current (active) heat setpoint shall be the occupied heating setpoint of 72 degrees F. (adjustable) plus or minus 1-degree F. from the slide dial setpoint adjust. The current (active) cool setpoint shall be the occupied cooling setpoint of 74 degrees F. (adjustable) plus or minus 1-degree F. from the slide dial setpoint adjust. There should be a heating differential setpoint of 2 degrees (adjustable) and a cooling differential setpoint of 2 degrees (adjustable).
      b. When the zone temperature is at the current (active) heat setpoint the zone heat demand shall be at 0%. When the zone temperature is below the heat setpoint by the heating differential setpoint the zone heat demand shall be a -100%. When the zone temperature is at the current (active) cool setpoint the zone cool demand shall be at 0%. When the zone temperature is above the cool setpoint by the cooling differential setpoint the zone cool demand shall be a 100%. This percentage shall be the coil/damper zone demand.
      c. When the zone temperature is between the current (active) heating and cooling setpoints (inside of the bias), the air damper will be at the minimum and the reheat valve will be fully closed. On a rise in zone temperature above the current (active) cooling setpoint, the air damper will increase the cfm and the reheat valve remains fully closed, if the VUV discharge air is below the zone setpoint. The maximum air damper position shall not exceed the zone cool demand percent. There shall be a max air disabled point which can be activated from the head end to disable this feature. On a drop in zone temperature below the current (active) heating setpoint, the reheat valve modulates open and the damper is controlled to provide the minimum and modulate past minimum to max cfm if temperature continues to fall. The maximum air damper position shall not exceed the absolute value of the zone heat demand percent. There shall be a max air disabled point which can be activated from the head end to disable this feature.
      d. The BAS Contractor shall furnish and install a wall mounted CO2 sensor in each room for each coil/damper and provide all programming for demand control ventilation operation, CO2 setpoints and damper position setpoints. When the room CO2 is below the Low CO2 of 750 PPM (adjustable) the damper shall in control. When the room CO2 is above the High CO2 of 1000 PPM (adjustable) the damper shall open its damper to Minimum Position Setpoint of 10% (adjustable) (this shall be a modulated reset open with 750 being 0 and 1,000 being at the Min Position Set Point). The damper will modulate past minimum when necessary, as stated above.

3. Unoccupied Cycle:
    a. In the unoccupied mode, when the room temperature falls below the Unoccupied Heating ON Setpoint of 60 degrees F. (adjustable) the valve and damper shall be commanded to 100%, once the space temperature reaches the Unoccupied Heating Off setpoint of 62 degrees F. (adjustable) the valve and damper shall go to its min position as described below and the fan shall be commanded to OFF.
    b. The heating valve shall modulate to its minimum. The minimum will be Valve Min Percent of 30% (adjustable) when the outside air temperature falls below the Valve Min OA of 35 degrees F. (adjustable) above this outside air temperature the valve shall remain closed.
    c. There will be no nighttime cooling.
    d. There shall be an occupied override button to return the unit to occupied. The occupied override time shall be 30 minutes adjustable.
    e. When the unit is unoccupied there shall be a Valve Exercise Enable point, which can be cycled from the head end computer. As long as the unit is unoccupied the valve exercise shall occur regardless whether it is in summer or winter mode. The valve shall be cycled to 100% for the valve exercise time of 3 minutes (adjustable), then cycled to 0% using the same valve exercise time stated above, then released to the percent it is calling for.
4. Safeties and Alarms:
    a. An alarm shall be noted in the event of a low and/or high temperature limit in the zone sensor.
5. Use Control Valve to provide local chilled water isolation and control if not provided by ACV shown on plans (when chiller is on valve is to be commanded to 0).
6. Points List:
    a. Inlet Air Temperature (located in supply duct off of VUV)
    b. Discharge Air Temperature
    c. Room Temperature
    d. Occupied Heating Setpoint
    e. Current (Active) Heat Setpoint
    f. Occupied Cooling Setpoint
    g. Current (Active) Cool Setpoint
    h. Room CO2 Sensor (furnished, installed and programmed for Demand Control Ventilation by BAS)
    i. Setpoint Adjustment (plus/minus 1 degrees F.)
    j. Boiler/Chiller Enable
    k. Reheat Valve – Command (furnished and wired by BAS contractor)
    l. Reheat Valve – Position
    m. Occupied/Unoccupied Mode
    n. Unoccupied Heating ON Setpoint
    o. Unoccupied Heating OFF Setpoint
    p. Occupied Override Time
    q. Valve Minimum Percent
    r. Valve Min, OA
    s. Valve Exercise Enable
    t. Valve Exercise Time
    u. Heating Differential Setpoint
    v. Cooling Differential Setpoint
    w. Low CO2
    x. High CO2
    y. CO2 Level
    z. Minimum Position Setpoint
    aa. Damper – Command
    bb. Damper – Position
    cc. Damper – Minimum Position Setpoint

M. Miscellaneous Exhaust Fan Control
1. Controls, controllers, and relays shall be mounted in hinge control boxes installed in the boiler room and/or mechanical mezzanine in locations and minimum size boxes shown in the electrical drawings, at an accessible height for servicing. Verify location with Architects, Engineers, and Owner.
2. All exhaust fans shall be provided with a relay for on/off control and a 0-to-10-volt signal to the fans ECM motor to set the balance of the fan. Provide speed balance setpoint 10 volts (adjustable) and set based on balancers requirements
3. All exhaust fans that are furnished with motorized back draft dampers by the manufacturer shall be field wired and controlled by the BAS Contractor, see exhaust fan schedule. In the unoccupied cycle backdraft dampers shall remain closed, in the occupied cycle the damper shall open when the OA temperature is above the exhaust lock setpoint of 40 degrees F. (adjustable) after a 1-minute delay the exhaust shall be allowed to run so long as the motorized backdraft end switch has been made.
4. Some exhaust fans will have a local momentary push button controls, furnished and install by the BAS Contractor. momentary push button controls shall be wired into a binary input to allow the fans, in the spaces with momentary push button controls, to turn on for the push button enable time of 15 minutes (adjustable). In order for the fan to come on the push button timer must be on and an occupied schedule for that exhaust fan must also be on. See exhaust fan schedule.
5. Thermostatically controlled fans will be controlled by the BAS system. The BAS Contractor will provide space temperature sensor to an analog input on the controller. In the occupied mode the fan shall turn on with the occupied on setpoint of 72 degrees F. (adjustable). Then turn off at the occupied off set point which will be the occupied on setpoint minus the occupied setpoint differential of 2 degrees (adjustable) In the unoccupied mode the fan shall come on at the unoccupied on setpoint of 90 degrees F. (adjustable). Then turn off at the unoccupied off set point which will be the unoccupied on setpoint minus the unoccupied setpoint differential of 2 degrees (adjustable)
6. BAS system will show status (on/off) of all exhaust fans installed through a current sensor for each fan (current sensing relays are not allowed must provide separate control relay and current sensor for each fan). Issue a non-critical alarm on failure. Fans as scheduled shall have start stop point on BAS.
7. All fans indicated on plans shall be monitored by BAS shall show start/stop and status points through BAS graphics and alarm on failure. -
8. Interlock associated intake or exhaust air dampers with exhaust fan. The controller shall turn on the exhaust damper with a separate binary out. The end switch on motorized dampers shall be wired to an input on control computer so we can monitor the status of the damper. The controller will not start the fan until the damper has an open status. Furnish, remove/replace damper operator if required.
9. Interlock with associated air supply unit as called for on exhaust fan schedule or drawings.
10. Control VFD’s connected to exhaust fans associated with air handling units and/or unit ventilators to maintain space pressure requirements (as described in Building Excess Pressure Control).
11. Refer to exhaust fan schedule on contract documents for additional control requirements.

12. Points List for each fan:
    a. Fan Start/Stop (All Fans)
    b. Fan Status (All Fans)
    c. Fan Fail (Alarm) (All Fans)
    d. Occupied / Unoccupied (All Fans)
    e. Space Temperature when required
    f. Occupied On Setpoint when required
    g. Unoccupied On Setpoint when required
    h. Exhaust Lock Setpoint when required
    i. Momentary Push Button when required
    j. Exhaust Backdraft Damper when required
    k. Exhaust Backdraft Damper Status when required
    l. Intake Damper when required
    m. Intake Damper Status when required
    n. Push Button Enable Time
    o. Speed Balance Setpoint
    p. Occupied Setpoint Differential
    q. Unoccupied Setpoint Differential

N. Building Excess Pressure Control
1. Controls, controllers, and relays shall be mounted in hinge control boxes installed in the boiler room and/or mechanical mezzanines at an accessible height for servicing. Verify location with Architects, Engineers, and Owner.
2. The BAS control will tie the unit ventilators and pressure relief exhaust fans into the BAS thru the connections on the frequency drive furnished by the BAS contractor to the electrical contractor for his mounting and wiring.
3. The unit ventilators that are located in the areas served by the exhaust fan shall be grouped.
4. The BAS contractor shall monitor the outside air damper position for the group of unit ventilators served by each exhaust fan and turn on when the average outside air exceeds the unit ventilator OA average setpoint of 20% (adjustable). The average outside air position shall be all outside air damper positions added together for the unit ventilators served and then divided by the number of unit ventilators. The fan shall run based on this average if the average is at 20%, then the fan should be at 20%. When the average OA damper is at 100% then the exhaust fan shall be at the exhaust high percent setpoint of 90% (adjustable). Interlock associated motorized exhaust air damper with exhaust fan. The controller shall turn on the exhaust damper with a separate binary out. The end switch on motorized dampers shall be wired to an input on control computer so we can monitor the status of the damper. The controller will not start the fan until the damper has an open status. Furnish, remove/replace damper operator if required. In Unoccupied mode fan shall remain off and damper shall be closed. See also Miscellaneous Exhaust Fan Control for additional information.
5. Points List:
    a. Fan Start/Stop (hard wired point)
    b. Fan Status (hard wired point)
    c. Fan Fail (Alarm) (hard wired points)
    d. Fan Speed Control 0 to 10 VDC (hard wired point)
    e. Space Pressure
    f. Pressure Setpoint
    g. Occupied / Unoccupied
    h. Exhaust Backdraft Damper
    i. Exhaust Backdraft Damper Status
    j. Unit ventilator OA Average
    k. Exhaust High Percent
    l. All available VFD points through SA Bus or BACnet data connection

O. Unit Heater SUH and CUH Control
   1. General:
      a. If the Boiler/Chiller Enable point is in state 1 Boiler mode the unit heater should be allowed to run otherwise it should remain off.
      b. When hot water supply temperature is 90 degrees F or greater as determined by BAS, the unit heater shall be permitted to run.
      c. Use Control Valve to provide local chilled water isolation and control if not provided by ACV shown on plans (when chiller is on valve is to be commanded to 0).
      d. All unit heaters shall be provided with a relay for on/off control and a 0 to 10-volt signal to the fans ECM motor to set the balance of the fan. Provide speed balance setpoint 10 volts (adjustable) and set based on balancers requirements
      e. Controls, controllers, and relays shall be mounted in hinge control boxes installed in the boiler room and/or mechanical mezzanines at an accessible height for servicing. Verify location with Architects, Engineers, and Owner.
   2. Occupied Cycle Heating:
      a. In the Occupied mode, the Heater shall cycle to maintain space temperature. When the room temperature falls below the Occupied Heating On Setpoint of 70 degrees F. (adjustable) the valve shall be commanded to 100% and the fan shall be commanded to ON, once the space temperature reaches the Occupied Heating Off setpoint of 72 degrees F. (adjustable) the valve shall go to its min position as described below and the fan shall be commanded to OFF.
      b. Provide Discharge Air Temperature for troubleshooting purposes from the head end.
   3. Unoccupied Cycle Heating Mode:
      a. In the unoccupied mode, the Heater shall cycle to maintain night setback temperature. When the room temperature falls below the Unoccupied Heating On Setpoint of 58 degrees F. (adjustable) the valve shall be commanded to 100% and the fan shall be commanded to ON, once the space temperature reaches the Unoccupied Heating Off setpoint of 60 degrees F. (adjustable) the valve shall go to its min position as described below and the fan shall be commanded to OFF. If boiler is not enabled fan shall remain off.
      b. The heating valve shall modulate to its minimum. The minimum will be Valve Min Percent of 30% (adjustable) when the outside air temperature falls below the Valve Min OA of 35 degrees F. (adjustable) above this outside air temperature the valve shall remain closed.
      c. When the unit is unoccupied there shall be a Valve Exercise Enable point, which can be cycled from the head end computer. As long as the unit is unoccupied the valve exercise shall occur regardless whether it is in summer or winter mode. The valve shall be cycled to 100% for the valve exercise time of 3 minutes (adjustable), then cycled to 0% using the same valve exercise time stated above, then released to the percent it is calling for.
   4. The following points shall be monitored through the BAS system:
      a. Unit Heater Fan Start/Stop.
      b. Unit Heater Fan Status – Off/On.
      c. Room Temperature.
      d. Hot Water Valve Command (furnished and wired by the BAS contractor).
      e. Hot Water Valve position.
      f. Occupied/Unoccupied Mode.
      g. Occupied Heating On Setpoint
      h. Occupied Heating Off Setpoint
      i. Unoccupied Heating On Setpoint
      j. Unoccupied Heating Off Setpoint
      k. Speed Balance Setpoint
      l. Discharge Air Temperature
      m. Valve Exercise Enable
      n. Valve Exercise Time

P. Classroom Unit Ventilator Control (Heating/Cooling Valve Control) ASHRAE Cycle II.
   1. General:
      a. Unit Ventilators will be provided with factory mounted DDC interface package as specified below. All other controls to be furnished and installed by BAS contractor in the field:
         1) Electrical damper operators (OA/RA) supplied by unit manufacturer. (Belimo Only) 2-10 VDC.
         2) Fused control transformer supplied by unit manufacturer.
         3) Low limit thermostat.
         4) Fan start/stop relay.
         5) Fan speed control (0 to 10 VDC).
         6) All components wired and terminated in an isolated box. Box to have terminal strip for connections.
      b. Provide separate space sensor and CO2 sensor for each classroom.
      c. Controls, controllers, and relays shall be mounted in unit ventilators control cabinet at an accessible height for servicing. **Verify location with Architects, Engineers, and Owner. Provide mock-up for review by Owner and Engineer.**
      d. BAS Contractor to feed a system enable point into the AHU Controller consisting of 0 equals system off, 1 equals boiler enabled, and 2 equals chiller enabled to control heating/cooling valve. If in State 0 the controller shall only run the outside air damper as described below
   2. Occupied Cycle Heating:
      a. The current (active) heat setpoint shall be the occupied heating setpoint of 72 degrees F. (adjustable) plus or minus 1-degree F. from the slide dial setpoint adjust.
      b. The BAS shall communicate to the classroom unit if the system is in the winter or summer mode. If in winter mode, the fan will operate continuously. Controller to cycle fan through infinite speed control range as required to meet room conditions. The outdoor air damper will be opened (subject to the mixed air low limit thermostat) to a minimum position (adjustable). On a call for heat, the heating valve (N.O.) shall modulate under control of the space temperature sensor.
      c. A low temperature freeze protection thermostat located on the discharge of the water coil, shall upon sensing a drop in temperature below its setpoint, 38 degrees F. (adjustable), spring open the control valve, shut down the unit vent fan and spring close the fresh air damper. This control must be automatically reset.
      d. Once the space temperature setpoint is reached, the outdoor air damper will modulate open above minimum setting to keep space from overheating using the current (active) cooling setpoint described in “Occupied Cycle Cooling”.
      e. The discharge air low limit (DALL) reset shall be from the Low setpoint of 50 degrees F. (adjustable) at the Low OA setpoint of 60 degrees F. (adjustable) outside air to the High setpoint of 65 degrees F. (adjustable) at High OA setpoint of 35 degrees F. (adjustable) outside air temperature.
      f. If the discharge air temperature drops below the DALL the outdoor air damper will modulate to minimum and the 2-way valve shall modulate to provide required heat to maintain the discharge temperature.
   3. Occupied Cycle Cooling:
      a. The current (active) cool setpoint shall be the occupied cooling setpoint of 74 degrees F. (adjustable) plus or minus 1-degree F. from the slide dial setpoint adjust.
      b. The BAS shall communicate to the classroom unit if the system is in the winter or summer mode. If in summer mode, the fan will operate continuously. Controller to cycle fan through infinite speed control range as required to meet room conditions. The cooling valve shall modulate to maintain space temperature after the outdoor air damper modulates through the Economizer Control sequence as stated below. The cooling valve shall modulate closed to maintain the discharge air low limit reset as described in Occupied Cycle Heating sequence as stated above.

c. Economizer Control: The BAS shall provide outside air temperature to the controller. If chilled water is available and the outdoor air temperature is over the Economizer Enable Setpoint of 68 degrees F. (adjustable) dry bulb, then the outdoor air damper will return to its minimum position. If chilled water is not available and the outdoor air temperature is higher than the space temperature, then the outdoor air damper will return to its minimum position. If both of these conditions don't exist the outdoor air damper shall modulate to maintain the space temperature and the discharge air low limit reset as described in Occupied Cycle Heating sequence as above.

4. Morning Warm Up Cycle:
   a. The outdoor air damper will remain closed, the 2-way heating valve shall open to full heat, the unit will run continuously in its highest speed. Once the space temperature setpoint is reached, the outdoor air damper, heating valve and unit will control as called for in "Occupied Cycle Heating".
   b. There shall be a warm up off delay of 10 minutes (adjustable) before outside air damper is allowed to open.
5. Unoccupied Cycle:
   a. In the unoccupied winter mode when boiler is enabled, the unit ventilator shall cycle to maintain night setback temperature. When the room temperature falls below the Unoccupied Heating On Setpoint of 58 degrees F. (adjustable) the valve shall be commanded to 100% and the fan shall be commanded to its highest speed, once the space temperature reaches the Unoccupied Heating Off setpoint of 60 degrees F. (adjustable) the valve shall go to its min position as described below and the fan shall be commanded to OFF. If boiler is not enabled fan shall remain off
   b. The outdoor air damper will remain closed and the heating valve shall modulate to its minimum. The minimum will be Valve Min Percent of 30% (adjustable) when the outside air temperature falls below the Valve Min OA of 35 degrees F. (adjustable) above this outside air temperature the valve shall remain closed.
   c. If mixed air or discharge air temperature falls below the Unoccupied Low Limit On setpoint of 40 degrees F. (adjustable) the heating valve shall modulate to 100% until all sensors are above the Unoccupied Low Limit Off setpoint of 50 degrees F. (adjustable).
   d. Valve remains full open and the fan shall be commanded to off on any freeze stat activation.
   e. There will be no nighttime cooling.
   f. There shall be an occupied override button to return the unit to occupied. The occupied override time shall be 30 minutes adjustable.
   g. When the unit is unoccupied there shall be a Valve Exercise Enable point, which can be cycled from the head end computer. As long as the unit is unoccupied the valve exercise shall occur regardless whether it is in summer or winter mode. The valve shall be cycled to 100% for the valve exercise time of 3 minutes (adjustable), then cycled to 0% using the same valve exercise time stated above, then released to the percent it is calling for.
6. Outdoor Air Damper Control:
   a. The BAS Contractor shall furnish and install a wall mounted CO2 sensor in the classroom for each Unit Ventilator and provide all programming for demand control ventilation operation, CO2 setpoints and damper position setpoints.
   b. When the room CO2 is below the Low CO2 of 750 PPM (adjustable) the damper shall be closed unless in economizer mode.
   c. When the room CO2 is above the High CO2 of 1000 PPM (adjustable) the damper shall open to the Outdoor Air Damper – Minimum Position Setpoint of 10% (adjustable) setpoint unless in economizer mode (this shall be a modulated reset open with 750 being 0 and 1,000 being at the Min Position Set Point).
   d. When free cooling is available the outdoor air damper shall control to maintain the discharge air low limit reset as described under the "Occupied Cycle Heating" or "Occupied Cycle Cooling" and allow for chilled water to supplement cooling when available.

7. The following points shall be monitored through the BAS system:
   a. Unit Ventilator Start/Stop.
   b. Unit Ventilator Status – Off/On.
   c. Room Temperature.
   d. Discharge Air Temperature
   e. Outdoor Air Temperature (global software point).
   f. Water in Temperature (global software point).
   g. Chilled & Hot water Valve - Command (furnished and wired by the BAS contractor).
   h. Chilled & Hot water Valve - Position.
   i. Outdoor Air Damper - Command
   j. Outdoor Air Damper – Position.
   k. Outdoor Air Damper – Minimum Position Setpoint.
   l. Relief Hood Motorized Damper - Control.
   m. Relief Hood Motorized Damper – Position
   n. Occupied Cooling Setpoint.
   o. Current (Active) Cool Setpoint.
   p. Occupied Heating Setpoint
   q. Current (Active) Heat Setpoint.
   r. Unoccupied Heating On Setpoint
   s. Unoccupied Heating Off Setpoint
   t. Room CO2 Sensor (furnished, installed, and programmed for Demand Control Ventilation by BAS).
   u. Setpoint Adjustment (plus/minus 1 degrees F.).
   v. Occupied/Unoccupied Mode.
   w. Low Limit Safety.
   x. Discharge Air Low Limit
   y. Boiler/Chiller Enabled
   z. Econ Enable Setpoint
   aa. Valve Min Percent
   bb. Valve Min OA
   cc. Low CO2
   dd. High CO2
   ee. Occupied Override Time
   ff. DALL Low Setpoint
   gg. DALL Low OA Setpoint
   hh. DALL High Setpoint
   ii. DALL High OA Setpoint
   jj. Unoccupied Low Limit On
   kk. Unoccupied Low Limit Off
   ll. Valve Exercise Enable
   mm. Valve Exercise Time
   nn. Warm Up Off Delay
   oo. Min Position Setpoint

Q. Fan Coil Unit Control
   1. General
      a. Fan Coil Units will be provided with field mounted controls to meet sequences specified below:
      b. Controls, controllers, and relays shall be mounted in hinge control boxes installed in the Boiler Room and/or Mechanical Mezzanines at an accessible height for servicing. Verify location with Architects, Engineers, and Owner.
      c. BAS Contractor to feed a system enable point into the AHU Controller consisting of 0 equals system off, 1 equals boiler enabled, and 2 equals chiller enabled to control heating/cooling valve.

2. Occupied Cycle Heating:
   a. The current (active) heat setpoint shall be the occupied heating setpoint of 72 degrees F. (adjustable) plus or minus 1-degree F. from the slide dial setpoint adjust.
   b. If in State 1 Boiler Enabled, the fan will operate continuously. Controller to cycle fan through infinite speed control range as required to meet room temperature setpoint. On a call for heat, the heating valve (N.O.) shall modulate under control of the space temperature sensor.
   c. The discharge air low limit (DALL) reset shall be from the Low setpoint of 50 degrees F. (adjustable) at the High OA setpoint of 60 degrees F. (adjustable) outside air to the High setpoint of 65 degrees F. (adjustable) at Low OA setpoint of 35 degrees F. (adjustable) outside air temperature.
   d. If the discharge air temperature drops below the DALL the 2-way valve shall modulate to provide required heat to maintain the discharge temperature.
3. Occupied Cycle Cooling:
   a. The current (active) cool setpoint shall be the occupied cooling setpoint of 74 degrees F. (adjustable) plus or minus 1-degree F. from the slide dial setpoint adjust.
   b. If in State 2 Chiller Enabled, the fan will operate continuously. Controller to cycle fan through infinite speed control range as required to meet room temperature setpoint the cooling valve shall modulate to maintain space temperature. The cooling valve shall modulate closed to maintain the discharge air low limit reset as described in Occupied Cycle Heating sequence as stated above
4. Morning Warm Up Cycle:
   a. The 2-way heating valve shall open to full heat and the unit will run continuously in its highest speed. Once the space temperature setpoint is reached, the heating valve and unit will control as called for in "Occupied Cycle Heating".
5. Unoccupied Cycle:
   a. In the unoccupied winter mode when boiler is enabled, the fan coil unit shall cycle to maintain night setback temperature. When the room temperature falls below the Unoccupied Heating On Setpoint of 58 degrees F. (adjustable) the valve shall be commanded to 100% and the fan shall be commanded to its highest speed, once the space temperature reaches the Unoccupied Heating Off setpoint of 60 degrees F. (adjustable) the valve shall go to its min position as described below and the fan shall be commanded to OFF. If boiler is not enabled fan shall remain off
   b. There will be no nighttime cooling.
   c. There shall be an occupied override button to return the unit to occupied. The occupied override time shall be 30 minutes adjustable.
   d. When the unit is unoccupied there shall be a Valve Exercise Enable point, which can be cycled from the head end computer. As long as the unit is unoccupied the valve exercise shall occur regardless whether it is in summer or winter mode. The valve shall be cycled to 100% for the valve exercise time of 3 minutes (adjustable), then cycled to 0% using the same valve exercise time stated above, then released to the percent it is calling for.
6. The following points shall be monitored through the BAS system:
   a. Fan Coil Unit Start/Stop.
   b. Fan Coil Unit Status – Off/On.
   c. Room Temperature.
   d. Discharge Air Temperature
   e. Outdoor Air Temperature (global software point).
   f. Water in Temperature (global software point).
   g. Chilled & Hot water Valve - Command (furnished and wired by the BAS contractor).
   h. Chilled & Hot water Valve - Position.
   i. Occupied Cooling Setpoint.
   j. Current (Active) Cool Setpoint.
   k. Occupied Heating Setpoint
   l. Current (Active) Heat Setpoint.

m. Unoccupied Heating On Setpoint
n. Unoccupied Heating Off Setpoint
o. Setpoint Adjustment (plus/minus 1 degrees F.).
p. Occupied/Unoccupied Mode.
q. Boiler/Chiller Enabled
r. Econ Enable Setpoint
s. Valve Min Percent
t. Occupied Override Time
u. DALL Low Setpoint
v. DALL Low OA Setpoint
w. DALL High Setpoint
x. DALL High OA Setpoint
y. Valve Exercise Enable
z. Valve Exercise Time

R. Refrigerant Monitoring and Ventilation Control
1. Controls, controllers, and relays shall be mounted in hinged control boxes installed in the Boiler Room next to Chiller Room door. RD-6 will be mounted in Chiller Room at an accessible height for servicing. Verify location with Architects, Engineers, and Owner.
2. The BAS contractor shall provide a refrigerant monitor and mount the sensor(s) at a location that complies with the ASHRAE 95 standard.
3. A refrigeration monitor shall provide an analog output (0-10 VDC or 4-20ma) that corresponds to the level of refrigerant detected by the monitor.
   a. This signal shall be used to generate an electronic log of the refrigerant level in the Chiller Equipment Room.
   b. Any increase in detected refrigerant levels shall trigger a diagnostic alarm indicating a refrigerant leak and the system should be checked.
   c. The monitor shall have two binary outputs for alarm relay and fan relay both shall be wired to inputs in the refrigerant monitoring control
4. The Building Automation System graphical display shall include all points indicated in the points list and any others required to achieve the sequence of operation.
5. The Building Automation System shall be tied to the chiller equipment room ventilation system to provide control of both normal and purge ventilation of the chiller equipment room. Interlock the intake dampers to open any time the exhaust fan is running.
   a. Normal Operation: Under normal operation the exhaust fan shall cycle on to maintain room temperature. The fan shall be provided with a relay for on/off control and a 0 to 10 volt signal to the fans ECM motor to set the balance of the fan. Provide speed balance setpoint 5 volts (adjustable) and set based on balancers requirements The BAS Contractor will provide space temperature sensor to an analog input on the controller. In the occupied mode the fan shall turn on with the occupied on setpoint of 72 degrees F. (adjustable). Then turn off at the occupied off set point which will be the occupied on setpoint minus the occupied setpoint differential of 2 degrees (adjustable) In the unoccupied mode the fan shall come on at the unoccupied on setpoint of 90 degrees F. (adjustable). Then turn off at the unoccupied off set point which will be the unoccupied on setpoint minus the unoccupied setpoint differential of 2 degrees (adjustable). The OA damper on the intake hood shall open when the fan is on.
   b. When RD-6 or Alarm Contacts is ON the system will operate the fan’s VFD in Purge Mode until the concentration of refrigerant has dissipated. Provide an alarm for refrigerant level and fan operation. The OA damper on the intake hood shall open and exhaust fan shall run at high speed. All the hot water and domestic water heaters/boilers shall shut down. Alarm horn will sound.
6. The following points shall be monitored through the BAS system:
   a. Refrigerant Level.
   b. Exhaust Fan Start/Stop.
   c. Exhaust Fan Status.
   d. Exhaust Fan ECM Speed

e. Room Temperature
f. Occupied On Setpoint
g. Unoccupied On Setpoint
h. Speed Balance Setpoint
i. Occupied Setpoint Differential
j. Unoccupied Setpoint Differential
k. OA Intake Damper.
l. Exhaust Damper.
m. OA Intake Damper Status.
n. Exhaust Damper Status.
o. RD-6 Alarm (As Required).
p. RD-6 Fan (As Required).

S. Power Monitoring / Phase monitoring and Control System
1. Controls, controllers, and relays shall be mounted in hinged control boxes installed in the Main Electrical Room at an accessible height for servicing. Verify location with Architects, Engineers, and Owner.
2. Wire into power monitoring system for main building power. The building voltage must be monitored before the main disconnect switch so if the disconnect were to trip we could still see what the incoming voltages are before resetting the disconnect. The power meter shall consist of three split core CT's hinged at both axes with power metering electronics embedded inside a master CT. Alternatively provide a Veris system with CT's and a remote power monitoring system controller.
3. The meter shall report all items enumerated below. It shall report serially over a RS-485 network using Modbus RTU protocol (verify with electrical contractor). Provide a new driver and port card for the FX-series JACE to accept this signal.
4. The meter shall directly accept any voltage input from 208 to 480 VAC. Meter shall be calibrated as a system and be accurate to +/- 1% from 10% to 100% of the rated current over a temperature range of 0-60 degrees C. Meter shall conform to ANSI c12.1 metering standard.
5. The power meter shall be internally isolated to 2000 VAC. The power meter case isolation shall be 600VAC.
6. The power meter shall be available in amperage ranges as required by this project. See plans for specific power distribution requirements.
7. System shall monitor inbound power for the following variables:
   a. kKh, Consumption
   b. kW, Real Power
   c. kVAR, Reactive Power
   d. kVA, Apparent Power
   e. Power Factor
   f. Average Real Power
   g. Minimum Real Power
   h. Maximum Real Power
   i. Voltage, L-L
   j. Voltage, L-N
8. All point available through the meters Modbus RTU
9. Phase monitor system shall monitor each main power phase of the building. Upon loss of a phase or imbalance of the voltage on legs A, B, or C the BAS system shall shut down all pieces of equipment under its control such as (equipment on generator shall be restarted once generator is on as stated in Generator Control):
   a. Air Handling units
   b. Boilers and Chillers
   c. Pumps (3 Phase only)
   d. Variable Frequency drives
   e. Exhaust fans (3 Phase only)
   f. Unit Ventilators, fan coils, etc.

10. Once the alarm is cleared system shall restart equipment allowing a time delay between starts to prevent demand charges in doing so.

T. Outside Lighting Control
1. Controls, controllers, and relays shall be mounted in hinge control boxes installed in the Main Electric Room in locations and minimum size boxes shown in the electrical drawings, at an accessible height for servicing. Verify location with Architects, Engineers, and Owner.
2. BAS Contractor shall provide an outside lighting eye (photo cell light level) to a binary input on lighting controller. When the eye shows the control system that it has gotten dark outside the controller shall turn on all lighting circuits.
3. Each lighting circuit shall also have a schedule to bypass the eye and shut the lights off when owner does not want the circuits running.
4. Points (circuits) for Outside Light Control:
   a. Points:
      1) Outside Eye (Photo Cell Light Level)
      2) Front Door Light – Command
      3) Front Door Light – Schedule
      4) Main Driveway Pole – Command
      5) Main Driveway Pole – Schedule
      6) Garage – Command
      7) Garage – Schedule
      8) Exit Driveway Pole – Command
      9) Exit Driveway Pole – Schedule
      10) Exit 3 – Command
      11) Exit 3 – Schedule
      12) Front Door Pole – Command
      13) Front Door Pole – Schedule
      14) Exit 4 & 5 – Command
      15) Exit 4 & 5 – Schedule
      16) North Parking Lot Pole – Command
      17) North Parking Lot Pole – Schedule
      18) Exit 6 & 7 – Command
      19) Exit 6 & 7 – Schedule
      20) East Parking Lot Pole – Command
      21) East Parking Lot Pole – Schedule
      22) Commons Canopy – Command
      23) Commons Canopy – Schedule
      24) South Parking Lot Pole – Command
      25) South Parking Lot Pole – Schedule
      26) Gyn Doors – Command
      27) Gyn Doors – Schedule
      28) West Parking Lot Pole – Command
      29) West Parking Lot Pole – Schedule
      30) Exit 8 & Tech Room – Command
      31) Exit 8 & Tech Room – Schedule
      32) Main Parking Lot 50% Pole – Command
      33) Main Parking Lot 50% Pole – Schedule
      34) EC Playground – Command
      35) EC Playground – Schedule
      36) Main Parking Lot 100% Pole – Command
      37) Main Parking Lot 100% Pole – Schedule
      38) Boiler Room – Command
      39) Boiler Room – Schedule
      40) Bus Drop Off West Pole – Command
      41) Bus Drop Off West Pole – Schedule
      42) Bus Drop Off Middle Pole – Command

43) Bus Drop Off Middle Pole – Schedule
44) Bus Drop Off East Pole – Command
45) Bus Drop Off East Pole – Schedule
46) Playlot Driveway Pole – Command
47) Playlot Driveway Pole – Schedule
48) Playlot Pole – Command
49) Playlot Pole – Schedule
50) Playground Pole – Command
51) Playground Pole – Schedule
52) 300 Wing Bldg. Pole – Command
53) 300 Wing Bldg. Pole – Schedule
54) Back Bldg. Pole – Command
55) Back Bldg. Pole – Schedule
56) Exit E2 – Command
57) Exit E2 – Schedule

U. Electric Water Coolers
   1. Controls, controllers, and relays shall be mounted in hinge control boxes installed in the East, West, or Gym Deck Machinery Spaces in locations and minimum size boxes shown in the electrical drawings, at an accessible height for servicing. Verify location with Architects, Engineers, and Owner.
   2. Provide On/Off control of all water coolers.
   3. Separate all water coolers into six (6) control groups multiple relays may be needed per group of water coolers.
   4. Points for electric water coolers:
      a. Gym Washroom Water Coolers – Command
      b. EC Wing Washroom Water Coolers – Command
      c. 200 East Washroom Water Coolers – Command
      d. 200 West Washroom Water Coolers – Command
      e. 300 East Washroom Water Coolers – Command
      f. 300 West Washroom Water Coolers – Command

V. Generator Control
   1. Controls, controllers, and relays shall be mounted in hinge control boxes installed in the boiler room at an accessible height for servicing. Verify location with Architects, Engineers, and Owner.
   2. BAS Contractor shall be required to install all remote-control devices provided with generators and all related interconnecting wiring per manufacturer's instructions.
   3. BAS shall monitor generators through the BAS system.
      a. Generator Status
      b. Each ATS Status (minimum 2)
      c. Generator General Alarm
   4. BAS shall monitor time schedules applied to equipment, after a general power failure or phase loss occurrence BAS shall restart any equipment powered by the generator based upon scheduled ON time, ATS status and Generator status. Building shall not transfer to emergency power situation upon generator test. Once the normal power service is connected, system shall revert to the normal operating mode.
   5. Provide any necessary cards in the JACE to monitor all points available for each transfer switch through communication interface provide with each unit (3 total) MODBUS, one for generator and two for transfer switches. Verify/coordinate with electrical contractor.

END OF SECTION

SECTION 17800

TESTING, ADJUSTING AND BALANCING

PART 1 – GENERAL

1.1 SECTION INCLUDES
A. Testing, adjustment, and balancing of air systems.
B. Testing, adjustment, and balancing of hydronic systems.
C. Testing, adjustment and balancing of domestic hot water and tempered water circulating system loops for building system and domestic water heater.
D. Measurement of final operating condition of HVAC systems.

1.2 RELATED SECTIONS
A. General Conditions - Starting of Systems.
B. Division 15 Specifications.
C. Division 16 Specifications.
D. Division 17 Specifications.

1.3 REFERENCES
A. AABC - National Standards for Total System Balance.
B. ADC - Test Code for Grilles, Registers, and Diffusers.
C. ASHRAE 111 - Practices for Measurement, Testing, Adjusting, and Balancing of Building Heating, Ventilation, Air conditioning, and Refrigeration Systems.
D. NEBB - Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems.
E. SMACNA - HVAC Systems Testing, Adjusting, and Balancing.

1.4 SUBMITTALS
A. Submit under provisions of Division 1 General Requirements.
B. Submit name of adjusting and balancing agency for approval within 30 days after notice of award of Contract.
C. Field Reports: Indicate deficiencies in systems that would prevent proper testing, adjusting, and balancing of systems and equipment to achieve specified performance.
D. Prior to commencing work, submit report forms or outlines indicating adjusting, balancing, and equipment data required.
E. Submit draft copies of report for review prior to final acceptance of Project. Provide final copies for Architect/Engineer and for inclusion in operating and maintenance manuals.
F. Provide 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.
G. Test Reports: Indicate data on AABC National Standards for Total System Balance forms.
H. BAS Contractor shall provide to the Test & Balance Company the following minimum information to help expedite the initial review of the HVAC System:
    1. Provide design drawings and specifications for balancing review.
    2. Layout the project on data sheets to further review the design for correct total air flows, pump flows, box sizes, etc.
    3. Provide sheet metal shop drawings.
    4. Provide equipment submittals.
    5. Provide control company submittals.
I. BAS Contractor shall submit complete background experience of his proposed Air and Water Testing and Balancing Contractor for Architect/Engineer’s approval before executing a contract for the work.

1.5 PROJECT RECORD DOCUMENTS
A. Submit under provisions of Division 1 General Requirements.
B. Record actual locations of flow measuring stations, balancing valves and rough setting.

1.6 QUALITY ASSURANCE

A. The TAB firm shall be a sub-contractor to the Building Automation System (BAS) Contractor and have at least fifteen (15) years successful testing, adjusting and balancing experience on projects with testing and balancing requirements similar to those required for this project.
B. The TAB firm SHALL NOT BE THE ORIGINAL INSTALLER of the systems or equipment to be tested and shall not be related to any of the successful Mechanical Contractors. He shall otherwise act as an independent contractor that specializes in and whose business is limited to testing and balancing.
C. Work shall be done under the direct supervision of a qualified test and balance engineer employed by the TAB contractor. Instruments used by this contractor shall be accurately calibrated and maintained in good working order. If requested, tests shall be conducted in the presence of the Engineer or Owner.

1.7 SEQUENCING AND SCHEDULING

A. Sequence work to commence after completion of each system and schedule completion of work before Substantial Completion of Project. TBS Contractor shall coordinate his work with the Building Automation Contractor's work. Refer to Division 1 for Sequence of Construction for each school. TAB Contractor shall be required to start and stop work as required to accommodate phase sequence of each school.

PART 2 – PRODUCTS

2.1 ACCEPTABLE BALANCING COMPANIES

A. Aero Test and Balance.
B. Superior Test and Balance.
C. Independent Test and Balance.
D. International Test & Balance, Inc.
E. Nobel Air Test and Balance.

PART 3 – EXECUTION

3.1 EXAMINATION

A. Verify that systems are complete and operable before commencing work. Ensure the following conditions:
    1. Systems are started and operating in a 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. Fans are rotating correctly.
    7. Fire and volume dampers are in place and open.
    8. Air coil fins are 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 is minimized.
    12. Hydronic systems are flushed, filled, and vented.
    13. Pumps are rotating correctly.
    14. Proper strainer baskets are clean and in place.
    15. Service and balance valves are open.
    16. All automatic and manual dampers are operable and fully open.

B. Submit field reports. Report defects and deficiencies noted during performance of services which prevent system balance.
C. Beginning of work means acceptance of existing conditions.
D. A construction deviation field report must be submitted noting deviation or deficiencies in the above that would preclude or prevent system balance.

3.2 PREPARATION

A. Provide instruments required for testing, adjusting, and balancing operations. Make instruments available to Architect/Engineer to facilitate spot checks during testing.
B. Provide additional balancing devices as required.
C. All HVAC systems must have manufacturer's start-up reports prior to balancing systems.

3.3 INSTALLATION TOLERANCES

A. Air Handling Systems: Adjust to within plus or minus 5 percent of design for supply systems and plus or minus 10 percent of design for return and exhaust systems.
B. Air Outlets and Inlets: Adjust total to within plus 10 percent and minus 5 percent of design to space. Adjust outlets and inlets in space to within plus or minus 10 percent of design.
C. Hydronic Systems: Adjust to within plus or minus 10 percent of design.
D. Balance to reduce/eliminate objectionable noise and note on report as required.

3.4 ADJUSTING

A. Ensure recorded data represents actual measured or observed conditions.
B. Permanently mark 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.
E. At final inspection, recheck random selections of data recorded in report. Recheck points or areas as selected and witnessed by the Owner.

3.5 AIR SYSTEM PROCEDURE

A. Adjust air handling and distribution systems to provide required or design supply, return, exhaust fresh air quantities.
B. As a minimum, air system shall be prepared for testing in the following manner:
    1. Using pitot tube transverse, set main line dampers to deliver proper air volumes to zones.
    2. Using pitot tube transverse, set branch line dampers to deliver proper air volumes to air terminal outlets in each zone.
    3. Read CFM at each air terminal outlet and adjust to meet design requirements. Test and record items as listed in the following test procedures.
        a. Test and adjust fan RPM to design requirements.
        b. Test and record fan motor full amperes.
        c. Make pitot tube transverse of main air ducts and obtain design volume at fans.
        d. Test and record system static pressure at fan suction and discharge.
        e. Test and adjust system for design recirculated air volume.
        f. Test and adjust system for design outdoor air volume.
        g. Adjust main duct to proper design volume.
        h. Adjust zones to proper design volume supply and return/exhaust.
        i. Test and adjust each air terminal to within tolerance of 10 percent or as specified on the drawings.
    4. In cooperation with the control manufacturer's representative, who is responsible for setting adjustments of automatically operated dampers to operate as specified, indicated and/or noted, TAB agency shall check controls for proper operation and list controls requiring adjustment by control installer.
    5. Air terminal outlets shall be adjusted to minimize drafts. Adjust air patterns to match plans.

C. Adjust outside air automatic dampers, outside air, return air and exhaust dampers for design conditions.
D. Measure temperature conditions across outside air, return air and exhaust dampers to check leakage.
E. Where modulating dampers are provided, take measurements and balance at extreme conditions. Balance variable volume systems at maximum air flow rate, full cooling and at minimum air flow rate, full heating.
F. Measure building static pressure and adjust supply, return and exhaust air systems to provide required relationship between each to maintain approximately 0.02 inches positive static pressure near the building entries.
G. Test and Balancing Contractor shall be required to field measure and set the minimum outside air on ALL unit ventilators.
H. **The Mechanical contractor shall provide and install replacement sheaves, belts, pulleys, etc. as required to meet final balancing requirements.**
I. Measure outside air for each unit ventilator.

3.6 WATER SYSTEM PROCEDURE

A. Adjust water systems to provide required or design quantities in Heating Mode. Include all the information indicated below for both operating modes (two (2) complete water reports).
B. Use calibrated Venturi tubes, orifices or other metered fittings and pressure gauges to determine flow rates for system balance.
C. Adjust a minimum, hydronic systems shall be prepared for testing in the following manner:
    1. Complete air balance must have been accomplished before actual hydronic balance begins.
    2. Phase One:
        a. Open valves identified as "normally open" to full open position. Close coil bypass stop valves. Set mixing valves to full coil flow.
        b. Check pump rotation.
        c. Check expansion tanks to determine that they are not air bound and that the system is sufficiently full of fluid.
        d. Set temperature controls to terminals are calling for full operation. This should close automatic bypass valve.
        e. Check operation of automatic bypass valve.
        f. Check and set operating temperatures of central units to design requirements.
    3. Phase Two:
        a. Record pump data and system volume delivery.
        b. Adjust fluid flow through central units.
        c. Proceed to balance each coil by flow device measurement.
        d. Upon completion of flow readings and adjustments at coils, mark settings and record data.
            Note: No volume shall be adjusted at pump valves. Pump valves shall be left in wide open position. Pump valves shall be used for isolation.
    4. Phase Three:
        a. After adjustments to coils are made, recheck settings at the pumps.
        b. Record and check following items at each element:
            1) G.P.M. volume of each coil by flow device.
            2) Set-point of flow device or balancing valve.
            3) Pump operating suction and discharge pressures and final total discharge head.
            4) List mechanical specifications of pumps.
            5) Rated and actual running amperage of pump motor.
            6) Water metering device readings for total flow volume.
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 valves, valves and fittings. Do not use service or shut-off vales for balancing unless indexed for balance point.

F. Where available pump capacity is less than total flow requirements or individual system parts, full flow is one part may be simulated by temporary restriction of flow to other parts or proportionally balance system.
G. The purchaser of the pumps shall be responsible to trim and/or replace impellers as required to meet specified final flow requirements.

3.7 DOMESTIC WATER SYSTEM PROCEDURE

A. Adjust water systems to provide required or design quantities.
B. Use calibrated Venturi tubes, orifices, or other metered fittings 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.
F. Where available pump capacity is less than total flow requirements or individual system parts, full flow in one part may be simulated by temporary restriction of flow to other parts.
G. Verify that all control valves fail to safe position as specified.
H. Test all domestic circulating pumps scheduled and provide complete head sheets for operating conditions.
I. Balance circulating water flow rate through each water heater and storage tank.
J. Provide adequate time in the field for commissioning of the domestic hot water system and balancing of all components to achieve manufacturer’s recommended temperature rise through the heaters.
K. Balance water flow rate through each circuit of the domestic water system to provide instantaneous hot water at each plumbing fixture.
L. Test hot water temperature and flow at three plumbing fixtures (minimum) in each circuit and record water hot supply temperature and a 5 second intervals until final temperature is reached.
M. Make all adjustments to the domestic water system as required to achieve no more than 10 seconds from opening a hot water tap to achieving final water temperature at any fixture.

3.8 SCHEDULES

A. Equipment Requiring Testing, Adjusting, and Balancing (Including but Not Limited to):
    1. Terminal Heat Transfer Units
    2. Fans
    3. Air Coils
    4. Air Inlets and Outlets
    5. Unit Ventilators
    6. Air Handling Units
    7. Exhaust Fans
    8. Electric Water Coolers
    9. Plumbing Pumps
    10. HVAC Pumps
    11. Boilers
    12. Chillers
    13. Domestic Hot Water

B. Report Forms
   1. Title Page:
      a. Name of Testing, Adjusting, and Balancing Agency
      b. Address of Testing, Adjusting, and Balancing Agency
      c. Telephone number of Testing, Adjusting, and Balancing Agency
      d. Project name
      e. Project location
      f. Project Architect
      g. Project Engineer
      h. Project Contractor
      i. Project altitude
      j. Report date
   2. Summary Comments:
      a. Design versus final performance
      b. Notable characteristics of system
      c. Description of systems operation sequence
      d. Summary of outdoor and exhaust flows to indicate amount of building pressurization
      e. Nomenclature used throughout report
      f. Test conditions
   3. Instrument List:
      a. Instrument
      b. Manufacturer
      c. Model number
      d. Serial number
      e. Range
      f. Calibration date
   4. Electric Motors:
      a. Manufacturer
      b. Model/Frame
      c. HP/BHP
      d. Phase, voltage, amperage; nameplate, actual, no load
      e. RPM
      f. Service factor
      g. Starter size, rating, heater elements
      h. Sheave Make/Size/Bore
   5. V Belt Drive:
      a. Identification/location
      b. Required driven RPM
      c. Driven sheave, diameter and RPM
      d. Belt, size and quantity
      e. Motor sheave diameter and RPM
      f. Center to center distance, maximum, minimum, and actual
   6. Cooling Coil Data:
      a. Identification/number
      b. Location
      c. Service
      d. Manufacturer
      e. Air flow, design and actual
      f. Entering air DB temperature, design and actual
      g. Entering air WB temperature, design and actual
      h. Leaving air DB temperature, design and actual
      i. Leaving air WB temperature, design and actual
      j. Air pressure drop, design and actual

7. Water Heating Coil Data:
    a. Identification/number
    b. Location
    c. Service
    d. Manufacturer
    e. Air flow, design and actual
    f. Water flow, design and actual
    g. Water pressure drop, design and actual
    h. Entering water temperature, design and actual
    i. Leaving water temperature, design and actual
    j. Entering air temperature, design and actual
    k. Leaving air temperature, design and actual
    l. Air pressure drop, design and actual
8. Air Moving Equipment
    a. Location
    b. Manufacturer
    c. Model number
    d. Serial number
    e. Arrangement/Class/Discharge
    f. Air flow, specified and actual
    g. Return air flow, specified and actual
    h. Outside air flow, specified and actual
    i. Total static pressure (total external), specified and actual
    j. Inlet pressure
    k. Discharge pressure
    l. Sheave Make/Size/Bore
    m. Number of Belts/Make/Size
    n. Fan RPM
9. Return Air/Outside Air Data:
    a. Identification/location
    b. Design air flow
    c. Actual air flow
    d. Design return air flow
    e. Actual return air flow
    f. Design outside air flow
    g. Actual outside air flow
    h. Return air temperature
    i. Outside air temperature
    j. Required mixed air temperature
    k. Actual mixed air temperature
    l. Design outside/return air ratio
    m. Actual outside/return air ratio
10. Exhaust Fan Data:
    a. Location
    b. Manufacturer
    c. Model number
    d. Serial number
    e. Air flow, specified and actual
    f. Total static pressure (total external), specified and actual
    g. Inlet pressure
    h. Discharge pressure
    i. Sheave Make/Size/Bore
    j. Number of Belts/Make/Size
    k. Fan RPM

11. Duct Traverse:
    a. System zone/branch
    b. Duct size
    c. Area
    d. Design velocity
    e. Design air flow
    f. Test velocity
    g. Test air flow
    h. Duct static pressure
    i. Air temperature
    j. Air correction factor
12. Duct Leak Test:
    a. Description of ductwork under test
    b. Duct design operating pressure
    c. Duct design test static pressure
    d. Duct capacity, air flow
    e. Maximum allowable leakage duct capacity times leak factor
    f. Test apparatus
        1) Blower
        2) Orifice, tube size
        3) Orifice size
        4) Calibrated
    g. Test static pressure
    h. Test orifice differential pressure
    i. Leakage
13. 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 air flow
    h. Test (final) velocity
    i. Test (final) air flow
    j. Percent of design air flow

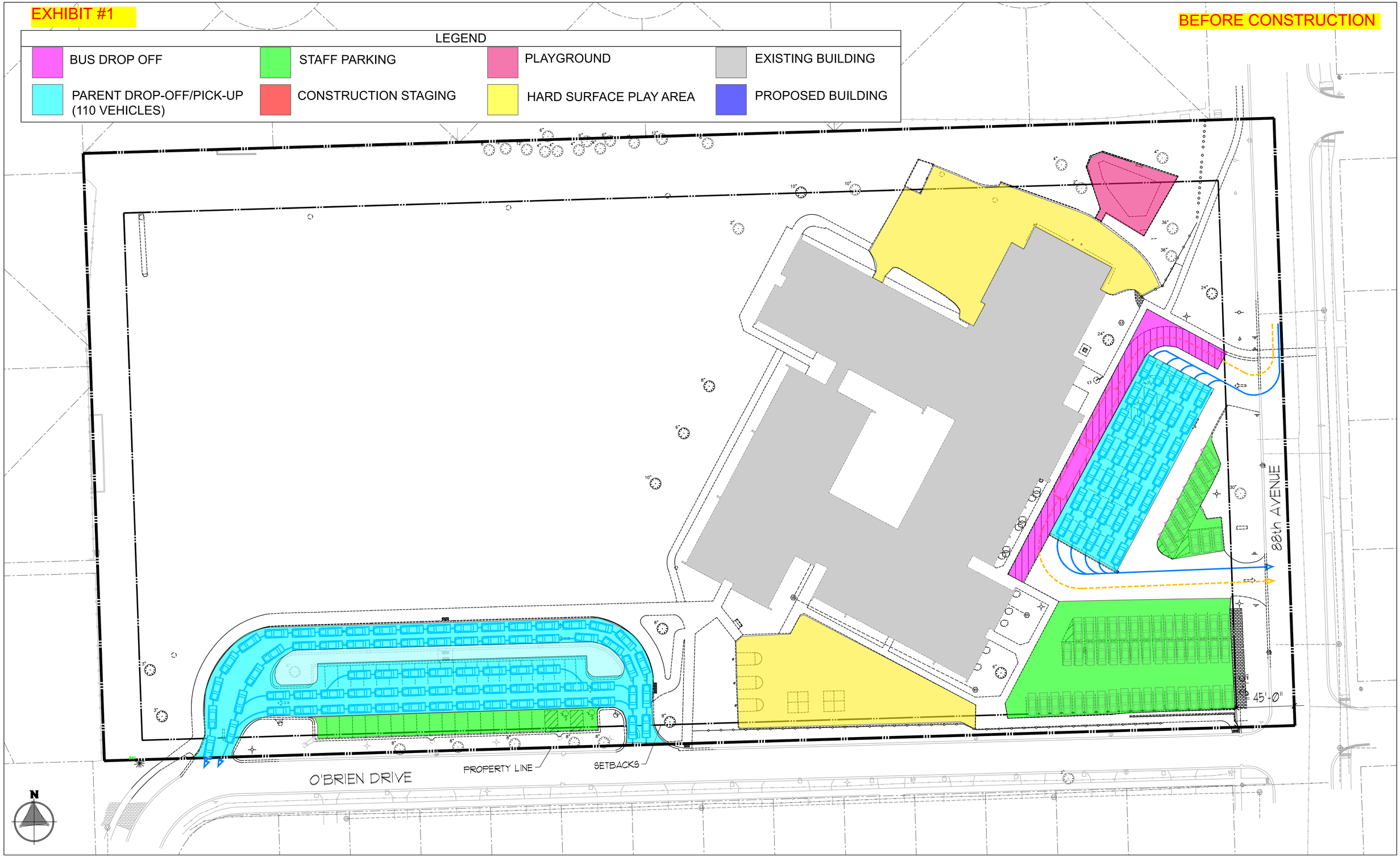
END OF SECTION

EXHIBIT #1

BEFORE CONSTRUCTION

LEGEND

- BUS DROP OFF
- STAFF PARKING
- PLAYGROUND
- EXISTING BUILDING
- PARENT DROP-OFF/PICK-UP (110 VEHICLES)
- CONSTRUCTION STAGING
- HARD SURFACE PLAY AREA
- PROPOSED BUILDING



D140 FERNWAY PARK ELEMENTARY SCHOOL

EXISTING SITE PLAN

TRIA ARCHITECTURE

09/27/2023

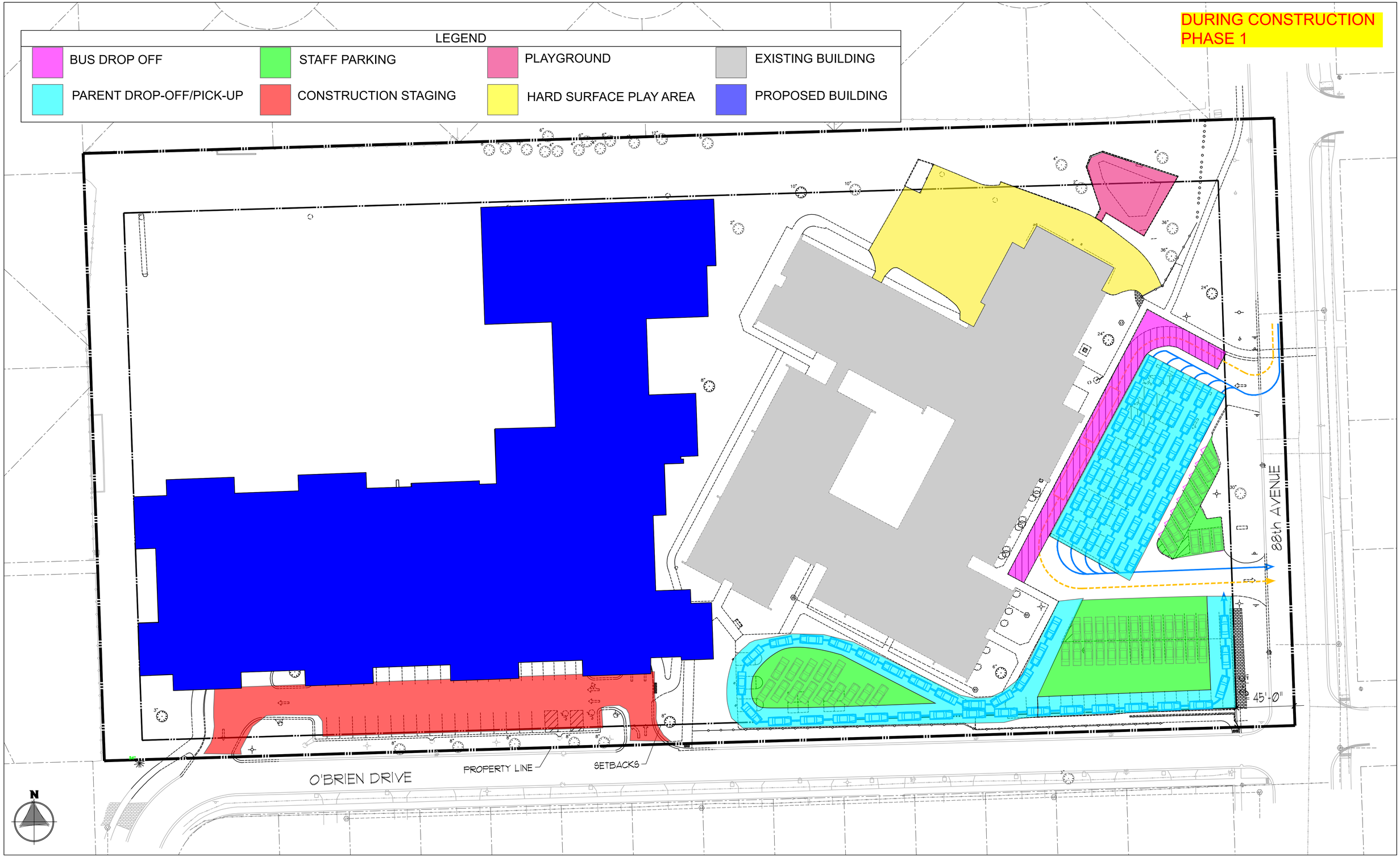
FOR REFERNCE ONLY

TRIA ARCHITECTURE

DURING CONSTRUCTION
PHASE 1

LEGEND

BUS DROP OFF	STAFF PARKING	PLAYGROUND	EXISTING BUILDING
PARENT DROP-OFF/PICK-UP	CONSTRUCTION STAGING	HARD SURFACE PLAY AREA	PROPOSED BUILDING



D140 FERNWAY PARK ELEMENTARY SCHOOL

EXISTING SITE PLAN AND PROPOSED BUILDING

TRIA ARCHITECTURE

09/27/2023

TRIA ARCHITECTURE

FOR REFERNCE ONLY

DURING CONSTRUCTION
PHASE 2

LEGEND

BUS DROP OFF	STAFF PARKING	PLAYGROUND	EXISTING BUILDING
PARENT DROP-OFF/PICK-UP	CONSTRUCTION STAGING	HARD SURFACE PLAY AREA	PROPOSED BUILDING

UNDER CONSTRUCTION

FUTURE

FUTURE

PROPERTY LINE

SETBACK LINE

O'BRIEN DRIVE

BOA AVENUE

N

D140 FERNWAY PARK ELEMENTARY SCHOOL

PROPOSED BUILDING AND SITE PLAN - PARENT DROP OFF/PICK-UP

TRIA ARCHITECTURE

09/27/2023

TRIA ARCHITECTURE

FOR REFERNCE ONLY

AFTER CONSTRUCTION

LEGEND

BUS DROP OFF	STAFF PARKING	PLAYGROUND	EXISTING BUILDING
PARENT DROP-OFF	CONSTRUCTION STAGING	HARD SURFACE PLAY AREA	PROPOSED BUILDING

FUTURE

FUTURE

PROPERTY LINE

SETBACK LINE

O'BRIEN DRIVE

88th AVENUE

N

D140 FERNWAY PARK ELEMENTARY SCHOOL

PROPOSED BUILDING AND SITE PLAN - PARENT DROP-OFF

TRIA ARCHITECTURE

09/27/2023

TRIA ARCHITECTURE

FOR REFERNCE ONLY

AFTER CONSTRUCTION

LEGEND

BUS DROP OFF	STAFF PARKING	PLAYGROUND	EXISTING BUILDING
PARENT PICK-UP	CONSTRUCTION STAGING	HARD SURFACE PLAY AREA	PROPOSED BUILDING

FUTURE

FUTURE

PROPERTY LINE

SETBACK LINE

O'BRIEN DRIVE

88th AVENUE

N

D140 FERNWAY PARK ELEMENTARY SCHOOL

PROPOSED BUILDING AND SITE PLAN - PARENT PICK-UP

TRIA ARCHITECTURE

09/27/2023

TRIA ARCHITECTURE

FOR REFERNCE ONLY