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Planning, Design, & Construction
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SPECIFICATIONS AND CONTRACT DOCUMENTS FOR

Missouri State University Blunt Hall Addition & Renovation Phase Two (Formally Temple Hall)

100% Construction Documents

Volume 4

Divisions 21 - 33

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BNIM PROJECT NO. 21031.01 MSU # 210611-116

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PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Requirements applicable to all Division 21 Sections. Also refer to Division 01 - General Requirements.

B. All materials and installation methods shall conform to the applicable standards, guidelines and codes referenced herein and within each specification section.

1.2 DIVISION OF WORK BETWEEN MECHANICAL, ELECTRICAL & CONTROL CONTRACTORS

A. Definitions:

1. "Mechanical Contractors" refers to the following:

    a. Plumbing Contractor.
    b. Heating Contractor.
    c. Air Conditioning and Ventilating Contractor.
    d. Temperature Control Contractor.
    e. Fire Protection Contractor.
    f. Testing, Adjusting, and Balancing Contractor.

2. Motor Control Wiring: The wiring associated with the remote operation of the magnetic coils of magnetic motor starters or relays, or the wiring that permits direct cycling of motors by means of devices in series with the motor power wiring. In the latter case the devices are usually single phase and are usually connected to the motor power wiring through a manual motor starter having "Manual-Off-Auto" provisions.
3. Control devices such as start-stop push buttons, thermostats, pressure switches, flow switches, relays, etc., generally represent the types of equipment associated with motor control wiring.
4. Motor control wiring is single phase and usually 120 volts. In some instances, the voltage will be the same as the motor power wiring. Generally, where the motor power wiring exceeds 120 volts, a control transformer is used to give a control voltage of 120 volts.
5. Temperature Control Wiring: The wiring associated with the operation of a motorized damper, solenoid valve or motorized valve, etc., either modulating or two-position, as opposed to wiring which directly powers or controls a motor used to drive equipment such as fans, pumps, etc.

    a. This wiring will be from a 120 volt source and may continue as 120 volt, or be reduced in voltage (24 volt) in which case a control transformer shall be furnished as part of the temperature control wiring.

6. Control Motor: An electric device used to operate dampers, valves, etc. It may be two-position or modulating. Conventional characteristics of such a motor are 24 volts, 60 cycles, 1 phase, although other voltages may be encountered.
7. Voltage is generally specified and scheduled as distribution voltage. Motor submittals may be based on utilization voltage if it corresponds to the correct distribution voltage.

Distribution/Nominal Voltage	Utilization Voltage
120	115
208	200
240	230
277	265
480	460

B. General:

1. The purpose of these Specifications is to outline the Electrical and Mechanical Contractor's responsibilities related to electrical work required for items such as temperature controls, mechanical equipment, fans, chillers, compressors and the like. The exact wiring requirements for much of the equipment cannot be determined until the systems have been selected and submittals reviewed. Therefore, the electrical drawings show only known wiring related to such items. All wiring not shown on the electrical drawings, but required for mechanical systems, is the responsibility of the Mechanical Contractor.
2. Where the drawings require the Electrical Contractor to wire between equipment furnished by the Mechanical Contractor, such wiring shall terminate at terminals provided in the equipment. The Mechanical Contractor shall provide complete electrical power/controls wiring diagrams and supervision to the Electrical Contractor and designate the terminal numbers for correct wiring.
3. All electrical work shall conform to the National Electrical Code. All provisions of the Electrical Specifications concerning wiring, protection, etc., apply to wiring provided by the Mechanical Contractor unless noted otherwise.
4. Control low (24V) and control line (120V) voltage wiring, conduit, and related switches and relays required for the automatic control and/or interlock of motors and equipment, including final connection, are to be furnished and installed under Divisions 21, 22 and 23. Materials and installation to conform to Class 1 or 2 requirements.
5. All Contractors shall establish utility elevations prior to fabrication and shall coordinate their material and equipment with other trades. When a conflict arises, priority is as follows:

    a. Light fixtures.
    b. Gravity flow piping, including steam and condensate.
    c. Electrical busduct.
    d. Sheet metal.
    e. Electrical cable trays, including access space.
    f. Sprinkler piping and other piping.
    g. Electrical conduits and wireway.

C. Mechanical Contractor's Responsibility:

1. Assumes responsibility for internal wiring of all equipment provided by the Mechanical Contractor, for example:

    a. Computer Room Air Conditioning Units.
    b. Condensate Return Stations.
    c. Condensing Units.
    d. Gas Trains.
    e. Package Air Handling Units.

2. Assumes all responsibility for the Temperature Control wiring, when the Temperature Control Contractor is a Subcontractor to the Mechanical Contractor.
3. Shall verify all existing equipment sizes and capacities where units are to be modified, moved or replaced. Contractor shall notify Architect/Engineer of any discrepancies <u>prior</u> to ordering new units or replacement parts, including replacements of equipment motors.
4. Temperature Control Contractor's Responsibility:

    a. Wiring of all devices needed to make the Temperature Control System functional.
    b. Verifying any control wiring on the electrical drawings as being by the Electrical Contractor. All wiring required for the Control System, but not shown on the electrical drawings, is the responsibility of the Temperature Control Contractor.
    c. Coordinating equipment locations (such as relays, transformers, etc.) with the Electrical Contractor, where wiring of the equipment is by the Electrical Contractor.

5. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

D. Electrical Contractor's Responsibility:

1. Provides all combination starters, manual starters and disconnect devices shown on the Electrical Drawings or indicated to be by the Electrical Contractor on the Mechanical Drawings or Specifications.
2. Installs and wires all remote control devices furnished by the Mechanical Contractor or Temperature Control Contractor when so noted on the Electrical Drawings.
3. Provides motor control and temperature control wiring, where so noted on the drawings.
4. Coordinate with the Mechanical Contractor for size of motors and/or other electrical devices involved with repair or replacement of existing equipment.
5. Furnishes, installs and connects all relays, etc., for automatic shutdown of certain fans upon actuation of the Fire Alarm System as indicated and specified in Division 28.
6. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

1.3 COORDINATION DRAWINGS

A. Definitions:

1. Coordination Drawings: A compilation of the pertinent layout and system drawings that show the sizes and locations, including elevations, of system components and required access areas to ensure that no two objects will occupy the same space.

   a. Mechanical trades shall include, but are not limited to, mechanical equipment, ductwork, fire protection systems, plumbing piping, medical gas systems, hydronic piping, steam and steam condensate piping, and any item that may impact coordination with other disciplines.
   b. Electrical trades shall include, but are not limited to, electrical equipment, conduit 1.5" and larger, conduit racks, cable trays, pull boxes, transformers, raceway, busway, lighting, ceiling-mounted devices, and any item that may impact coordination with other disciplines.
   c. Technology trades shall include, but are not limited to, technology equipment, racks, conduit 1.5" and larger, conduit racks, cable trays, ladder rack, pull boxes, raceway, ceiling-mounted devices, and any item that may impact coordination with other disciplines.
   d. Maintenance clearances and code-required dedicated space shall be included.
   e. The coordination drawings shall include all underground, underfloor, in-floor, in chase, and vertical trade items.

2. Spaces with open/cloud ceiling architecture shall indicate the overhead utilities and locate equipment as required to maintain clearance above lights. The intent for the installation is to maintain a maximum allowable vertical clearance and an organized/clean manner in the horizontal. Notify Architect/Engineer of the maximum clearance which can be maintained. Failure to comply will result in modifications with no cost to Owner.

   a. In cloud ceiling architecture, when open cabling/wire and/or cable tray crosses gaps between ceiling clouds and/or walls, cabling is to transition to conduits to span the gaps in order to conceal cabling from below.

3. The contractors shall use the coordination process to identify the proper sequence of installation of all utilities above ceilings and in other congested areas, to ensure an orderly and coordinated end result, and to provide adequate access for service and maintenance.

B. Participation:

1. The contractors and subcontractors responsible for work defined above shall participate in the coordination drawing process.
2. One contractor shall be designated as the Coordinating Contractor for purposes of preparing a complete set of composite electronic CAD coordination drawings that include all applicable trades, and for coordinating the activities related to this process. The Coordinating Contractor for this project shall be the Mechanical Contractor.

a. The Coordinating Contractor shall utilize personnel familiar with requirements of this project and skilled as draftspersons/CAD operators, competent to prepare the required coordination drawings.

3. Electronic CAD drawings shall be submitted to the Coordinating Contractor for addition of work by other trades. IMEG will provide electronic file copies of ventilation drawings for contractor's use if the contractor signs and returns an "Electronic File Transfer" waiver provided by IMEG. IMEG will not consider blatant reproductions of original file copies an acceptable alternative for coordination drawings.

C. Drawing Requirements:

1. The file format and file naming convention shall be coordinated with and agreed to by all contractors participating in the coordination process and the Owner.

a. Scale of drawings:

1) General plans: 1/4 Inch = 1'-0" (minimum).
2) Mechanical, electrical, communication rooms, and including the surrounding areas within 10 feet: 1/2 Inch = 1'-0" (minimum).
3) Shafts and risers: 1/2 Inch = 1'-0" (minimum).
4) Sections of shafts and mechanical and electrical equipment rooms: 1/4 Inch = 1'-0" (minimum).
5) Sections of congested areas: 1/2 Inch = 1'-0" (minimum).

2. Ductwork layout drawings shall be the baseline system for other components. Ductwork layout drawings shall be modified to accommodate other components as the coordination process progresses.
3. There may be more drawings required for risers, top and bottom levels of mechanical rooms, and shafts.
4. The minimum quantity of drawings will be established at the first coordination meeting and sent to the A/E for review. Additional drawings may be required if other areas of congestion are discovered during the coordination process.

D. General:

1. Coordination drawing files shall be made available to the A/E and Owner's Representative. The A/E will only review identified conflicts and give an opinion, but will not perform as a coordinator.
2. A plotted set of coordination drawings shall be available at the project site.
3. Coordination drawings are not shop drawings and shall not be submitted as such.
4. The contract drawings are schematic in nature and do not show every fitting and appurtenance for each utility. Each contractor is expected to have included in the bid sufficient fittings, material, and labor to allow for adjustments in routing of utilities made necessary by the coordination process and to provide a complete and functional system.
5. The contractors will not be allowed additional costs or time extensions due to participation in the coordination process.
6. The contractors will not be allowed additional costs or time extensions for additional fittings, reroutings or changes of duct size, that are essentially equivalent sizes to those shown on the drawings and determined necessary through the coordination process.
7. The A/E reserves the right to determine space priority of equipment in the event of spatial conflicts or interference between equipment, piping, conduit, ducts, and equipment provided by the trades.
8. Changes to the contract documents that are necessary for systems installation and coordination shall be brought to the attention of the A/E.
9. Access panels shall preferably occur only in gypsum board walls or plaster ceilings where indicated on the drawings.

a. Access to mechanical, electrical, technology, and other items located above the ceiling shall be through accessible lay-in ceiling tile areas.
b. Potential layout changes shall be made to avoid additional access panels.
c. Additional access panels shall not be allowed without written approval from the A/E at the coordination drawing stage.

d. Providing additional access panels shall be considered after other alternatives are reviewed and discarded by the A/E and the Owner's Representative.
e. When additional access panels are required, they shall be provided without additional cost to the Owner.

10. Complete the coordination drawing process and obtain sign off of the drawings by all contractors prior to installing any of the components.
11. Conflicts that result after the coordination drawings are signed off shall be the responsibility of the contractor or subcontractor who did not properly identify their work requirements, or installed their work without proper coordination.
12. Updated coordination drawings that reflect as-built conditions may be used as record documents.

1.4 QUALITY ASSURANCE

A. Contractor's Responsibility Prior to Submitting Pricing Data:

1. The Contractor is responsible for constructing complete and operating systems. The Contractor acknowledges and understands that the Contract Documents are a two-dimensional representation of a three-dimensional object, subject to human interpretation. This representation may include imperfect data, interpreted codes, utility guidelines, three-dimensional conflicts, and required field coordination items. Such deficiencies can be corrected when identified prior to ordering material and starting installation. The Contractor agrees to carefully study and compare the individual Contract Documents and report at once in writing to the Design Team any deficiencies the Contractor may discover. The Contractor further agrees to require each subcontractor to likewise study the documents and report at once any deficiencies discovered.
2. The Contractor shall resolve all reported deficiencies with the Architect/Engineer prior to awarding any subcontracts, ordering material, or starting any work with the Contractor's own employees. Any work performed prior to receipt of instructions from the Design Team will be done at the Contractor's risk.

B. Qualifications:

1. Only products of reputable manufacturers are acceptable.
2. All Contractors and subcontractors shall employ only workers skilled in their trades.

C. Compliance with Codes, Laws, Ordinances:

1. Conform to all requirements of the City of Springfield Missouri Codes, Laws, Ordinances and other regulations having jurisdiction.
2. Conform to all published standards of Missouri State University.
3. Conform to all State Codes.
4. If there is a discrepancy between the codes and regulations and these specifications, the Architect/Engineer shall determine the method or equipment used.
5. If the Contractor notes, at the time of bidding, that any parts of the drawings or specifications do not comply with the codes or regulations, Contractor shall inform the Architect/Engineer in writing, requesting a clarification. If there is insufficient time for this procedure, Contractor shall submit with the proposal a separate price to make the system comply with the codes and regulations.
6. All changes to the system made after letting of the contract, to comply with codes or requirements of Inspectors, shall be made by the Contractor without cost to the Owner.
7. If there is a discrepancy between manufacturer's recommendations and these specifications, the manufacturer's recommendations shall govern.
8. All rotating shafts and/or equipment shall be completely guarded from all contact. Partial guards and/or guards that do not meet all applicable OSHA standards are not acceptable. Contractor is responsible for providing this guarding if it is not provided with the equipment supplied.

D. Permits, Fees, Taxes, Inspections:

1. Procure all applicable permits and licenses.

2. Abide by all laws, regulations, ordinances, and other rules of the State or Political Subdivision where the work is done, or as required by any duly constituted public authority.
3. Pay all charges for permits or licenses.
4. Pay all fees and taxes imposed by the State, Municipal and/or other regulatory bodies.
5. Pay all charges arising out of required inspections by an authorized body.
6. Pay all charges arising out of required contract document reviews associated with the project and as initiated by the Owner or authorized agency/consultant.
7. Where applicable, all fixtures, equipment and materials shall be approved or listed by Underwriter's Laboratories, Inc.

E. Utility Company Requirements:

1. Secure from the appropriate private or public utility company all applicable requirements.
2. Comply with all utility company requirements.
3. Make application for and pay for fire protection water service connection.

F. Examination of Drawings:

1. The drawings for the fire protection work are completely diagrammatic, intended to convey the scope of the work and to indicate the general arrangements and locations of equipment, outlets, etc., and the approximate sizes of equipment.
2. Contractor shall determine the exact locations of equipment and rough-ins, and the exact routing of pipes and ducts to best fit the layout of the job.
3. Scaling of the drawings is not sufficient or accurate for determining these locations.
4. Where job conditions require reasonable changes in indicated arrangements and locations, such changes shall be made by the Contractor at no additional cost to the Owner.
5. Because of the scale of the drawings, certain basic items, such as fittings, boxes, valves, unions, etc., may not be shown, but where required by other sections of the specifications or required for proper installation of the work, such items shall be furnished and installed.
6. If an item is either on the drawings or in the specifications, it shall be included in this contract.
7. Determination of quantities of material and equipment required shall be made by the Contractor from the documents. Where discrepancies arise between drawings, schedules and/or specifications, the greater number shall govern.
8. Where used in fire protection documents, the word "furnish" shall mean supply for use, the word "install" shall mean connect complete and ready for operation, and the word "provide" shall mean to supply for use and connect complete and ready for operation.

   a. Any item listed as furnished shall also be installed, unless otherwise noted.
   b. Any item listed as installed shall also be furnished, unless otherwise noted.

G. Field Measurements:

1. Verify all pertinent dimensions at the job site before ordering any materials or fabricating any supports, pipes or ducts.

H. Electronic Media/Files:

1. Construction drawings for this project have been prepared utilizing Revit.
2. Contractors and Subcontractors may request electronic media files of the contract drawings and/or copies of the specifications. Specifications will be provided in PDF format.
3. Upon request for electronic media, the Contractor shall complete and return a signed "Electronic File Transmittal" form provided by IMEG.
4. If the information requested includes floor plans prepared by others, the Contractor will be responsible for obtaining approval from the appropriate Design Professional for use of that part of the document.
5. The electronic contract documents can be used for preparation of shop drawings and as-built drawings only. The information may not be used in whole or in part for any other project.
6. The drawings prepared by IMEG for bidding purposes may not be used directly for ductwork layout drawings or coordination drawings.
7. The use of these CAD documents by the Contractor does not relieve them from their responsibility for coordination of work with other trades and verification of space available for the installation.

8. The information is provided to expedite the project and assist the Contractor with no guarantee by IMEG as to the accuracy or correctness of the information provided. IMEG accepts no responsibility or liability for the Contractor's use of these documents.

1.5 SUBMITTALS

A. Submittals shall be required for the following items, and for additional items where required elsewhere in the specifications or on the drawings.

1. Submittals list:

Referenced Specification Section	Submittal Item
21 05 00	Owner Training Agenda
21 05 03	Fire Seal Systems
21 05 13	Motors
21 05 48	Vibration Isolation Equipment
21 05 50	Seismic Restraint Systems
21 13 00	Sprinkler Systems
21 13 00	Fire Protection Equipment
21 23 00	Fire Suppression Systems
21 22 00	Clean Agent Fire Suppression Systems
21 30 00	Fire Pumps

B. General Submittal Procedures: In addition to the provisions of Division 01, the following are required:

1. Transmittal: Each transmittal shall include the following:

a. Date
b. Project title and number
c. Contractor's name and address
d. Division of work (e.g., plumbing, heating, ventilating, etc.)
e. Description of items submitted and relevant specification number
f. Notations of deviations from the contract documents
g. Other pertinent data

2. Submittal Cover Sheet: Each submittal shall include a cover sheet containing:

a. Date
b. Project title and number
c. Architect/Engineer
d. Contractor and subcontractors' names and addresses
e. Supplier and manufacturer's names and addresses
f. Division of work (e.g., plumbing, heating, ventilating, etc.)
g. Description of item submitted (using project nomenclature) and relevant specification number
h. Notations of deviations from the contract documents
i. Other pertinent data
j. Provide space for Contractor's review stamps

3. Composition:

a. Submittals shall be submitted using specification sections and the project nomenclature for each item.
b. Individual submittal packages shall be prepared for items in each specification section. All items within a single specification section shall be packaged together where possible. An individual submittal may contain items from multiple specifications sections if the items are intimately linked (e.g., pumps and motors).

c. All sets shall contain an index of the items enclosed with a general topic description on the cover.

4. Content: Submittals shall include all fabrication, erection, layout, and setting drawings; manufacturers' standard drawings; schedules; descriptive literature, catalogs and brochures; performance and test data; electrical power criteria (e.g., voltage, phase, amps, horsepower, kW, etc.) wiring and control diagrams; Short Circuit Current Rating (SCCR); dimensions; shipping and operating weights; shipping splits; service clearances; and all other drawings and descriptive data of materials of construction as may be required to show that the materials, equipment or systems and the location thereof conform to the requirements of the contract documents.
5. Contractor's Approval Stamp:

   a. The Contractor shall thoroughly review and approve all shop drawings before submitting them to the Architect/Engineer. The Contractor shall stamp, date and sign each submittal certifying it has been reviewed.
   b. Unstamped submittals will be rejected.
   c. The Contractor's review shall include, but not be limited to, verification of the following:

      1) Only approved manufacturers are used.
      2) Addenda items have been incorporated.
      3) Catalog numbers and options match those specified.
      4) Performance data matches that specified.
      5) Electrical characteristics and loads match those specified.
      6) Equipment connection locations, sizes, capacities, etc. have been coordinated with other affected trades.
      7) Dimensions and service clearances are suitable for the intended location.
      8) Equipment dimensions are coordinated with support steel, housekeeping pads, openings, etc.
      9) Constructability issues are resolved (e.g., weights and dimensions are suitable for getting the item into the building and into place, sinks fit into countertops, etc.).

   d. The Contractor shall review, stamp and approve all subcontractors' submittals as described above.
   e. The Contractor's approval stamp is required on all submittals. Approval will indicate the Contractor's review of all material and a complete understanding of exactly what is to be furnished. Contractor shall clearly mark all deviations from the contract documents on all submittals. If deviations are not marked by the Contractor, then the item shall be required to meet all drawing and specification requirements.

6. Submittal Identification and Markings:

   a. The Contractor shall clearly mark each item with the same nomenclature applied on the drawings or in the specifications.
   b. The Contractor shall clearly indicate the size, finish, material, etc.
   c. Where more than one model is shown on a manufacturer's sheet, the Contractor shall clearly indicate exactly which item and which data is intended.
   d. All marks and identifications on the submittals shall be unambiguous.

7. Schedule submittals to expedite the project. Coordinate submission of related items.
8. Identify variations from the contract documents and product or system limitations that may be detrimental to the successful performance of the completed work.
9. Reproduction of contract documents alone is not acceptable for submittals.
10. Incomplete submittals will be rejected without review. Partial submittals will only be reviewed with prior approval from the Architect/Engineer.
11. Submittals not required by the contract documents may be returned without review.
12. The Architect/Engineer's responsibility shall be to review one set of shop drawing submittals for each product. If the first submittal is incomplete or does not comply with the drawings and/or specifications, the Contractor shall be responsible to bear the cost for the Architect/Engineer to recheck and handle the additional shop drawing submittals.
13. Submittals shall be reviewed and approved by the Architect/Engineer **before** releasing any equipment for manufacture or shipment.

14. Contractor's responsibility for errors, omissions. or deviation from the contract documents in submittals is not relieved by the Architect/Engineer's approval.
15. Schedule shall allow for adequate time to perform orderly and proper review of submittals, including time for consultants and Owner if required, and resubmittals by Contractor if necessary, and to cause no delay in Work or in activities of Owner or other contractors.

    a. Allow at least two weeks for Architect's/Engineer's review and processing of each submittal.

16. Architect/Engineer reserves the right to withhold action on a submittal which, in the Architect/Engineer's opinion, requires coordination with other submittals until related submittals are received. The Architect/Engineer will notify the Contractor, in writing, when they exercise this right.

C. Electronic Submittal Procedures:

1. Distribution: Email submittals as attachments to all parties designated by the Architect/Engineer, unless a web-based submittal program is used.
2. Transmittals: Each submittal shall include an individual electronic letter of transmittal.
3. Format: Electronic submittals shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Submittals that are not legible will be rejected. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.
4. File Names: Electronic submittal file names shall include the relevant specification section number followed by a description of the item submitted, as follows. Where possible, include the transmittal as the first page of the PDF instead of using multiple electronic files.

    a. Submittal file name: 21 XX XX.description.YYYYMMDD
    b. Transmittal file name: 21 XX XX.description.YYYYMMDD

5. File Size: Files shall be transmitted via a pre-approved method. Larger files may require an alternative transfer method, which shall also be pre-approved.

1.6 CHANGE ORDERS

A. A detailed material and labor takeoff shall be prepared for each change order, along with labor rates and markup percentages. Change orders shall be broken down by sheet or associated individual line item indicated in the change associated narrative, whichever provides the most detailed breakdown. Change orders with inadequate breakdown will be rejected.

B. Itemized pricing with unit cost shall be provided from all distributors and associated subcontractors.

C. Change order work shall not proceed until authorized.

1.7 EQUIPMENT SUPPLIERS' INSPECTION

A. The following equipment shall not be placed in operation until a competent installation and service representative of the manufacturer has inspected the installation and certified that the equipment is properly installed, adjusted and lubricated; that preliminary operating instructions have been given; and that the equipment is ready for operation:

1. Fire Seal Systems

B. Contractor shall arrange for and obtain supplier's on-site inspection(s) at proper time(s) to assure each phase of equipment installation and/or connection is in accordance with the manufacturer's instructions.

C. Submit copies of start-up reports to the Architect/Engineer and include copies of Owner's Operation and Maintenance Manuals.

1.8 PRODUCT DELIVERY, STORAGE, HANDLING & MAINTENANCE

A. Exercise care in transporting and handling to avoid damage to materials. Store materials on the site to prevent damage. Keep materials clean, dry and free from harmful conditions. Immediately remove any materials that become wet or that are suspected of becoming contaminated with mold or other organisms.

B. Keep all bearings properly lubricated and all belts properly tensioned and aligned.

C. Coordinate the installation of heavy and large equipment with the General Contractor and/or Owner. If the Mechanical Contractor does not have prior documented experience in rigging and lifting similar equipment, he/she shall contract with a qualified lifting and rigging service that has similar documented experience. Follow all equipment lifting and support guidelines for handling and moving.

D. Contractor is responsible for moving equipment into the building and/or site. Contractor shall review site prior to bid for path locations and any required building modifications to allow movement of equipment. Contractor shall coordinate the work with other trades.

1.9 NETWORK / INTERNET CONNECTED EQUIPMENT

A. These specifications may require certain equipment or systems to have network, Internet and/or remote access capability ("Network Capability"). Any requirement for Network Capability shall be interpreted only as a functional capability and is not to be construed as authority to connect or enable any Network Capability. Network Capability may only be connected or enabled with the express written consent of the Owner.

1.10 WARRANTY

A. Provide one-year warranty, unless otherwise noted, to the Owner for all fixtures, equipment, materials, and workmanship.

B. The warranty period for all work in this Division of the specifications shall commence on the date of final acceptance, unless a whole or partial system or any separate piece of equipment or component is put into use for the benefit of any party other than the installing contractor with prior written authorization. In this instance, the warranty period shall commence on the date when such whole system, partial system or separate piece of equipment or component is placed in operation and accepted in writing by the Owner.

C. Warranty requirements shall extend to correction, without cost to the Owner, of all Work found to be defective or nonconforming to the contract documents. The Contractor shall bear the cost of correcting all damage resulting from defects or nonconformance with contract documents.

1.11 INSURANCE

A. Contractor shall maintain insurance coverage as set forth in Division 0 of these specifications.

1.12 MATERIAL SUBSTITUTION

A. Where several manufacturers' names are given, the scheduled manufacturer is the basis for job design and establishes the quality required.

B. Equivalent equipment manufactured by the other listed manufacturers may be used. Contractor shall ensure that all items submitted by these other manufacturers meet all requirements of the drawings and specifications and fits in the allocated space. When using other listed manufacturers, the Contractor shall assume responsibility for any and all modifications necessary (including, but not limited to structural supports, electrical connections, piping and ductwork connections and arrangement, plumbing connections and rough-in, and regulatory agency approval, etc.) and coordinate such with other contractors.

C. Any material, article or equipment of other unnamed manufacturers which will adequately perform the services and duties imposed by the design and is of a quality equal to or better than the material, article or equipment identified by the drawings and specifications may be used if approval is secured in writing from the Architect/Engineer not later than ten days prior to the bid opening.

D. This Contractor assumes all costs incurred as a result of using the offered material, article or equipment, on the Contractors part or on the part of other Contractors whose work is affected.

E. This Contractor may list voluntary add or deduct prices for alternate materials on the bid form. These items will not be used in determining the low bidder.

F. All material substitutions requested later than ten (10) days prior to bid opening must be listed as voluntary changes on the bid form.

1.13 PROJECT COMMISSIONING

A. The Contractor shall work with the Commissioning Agent (CxA) as described in Section 21 08 00 and provide all services as described in the Commissioning Plan.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 JOBSITE SAFETY

A. Neither the professional activities of the Architect/Engineer, nor the presence of the Architect/Engineer or the employees and subconsultants at a construction site, shall relieve the Contractor and other entity of their obligations, duties and responsibilities including, but not limited to, construction means, methods, sequence, techniques or procedures necessary for performing, superintending or coordinating all portions of the work of construction in accordance with the contract documents and any health or safety precautions required by any regulatory agencies. The Architect/Engineer and personnel have no authority to exercise any control over any construction contractor or other entity or their employees in connection with their work or any health or safety precautions. The Contractor is solely responsible for jobsite safety. The Architect/Engineer and the Architect/Engineer's consultants shall be indemnified and shall be made additional insureds under the Contractor's general liability insurance policy.

3.2 EXCAVATION, FILL, BACKFILL, COMPACTION

A. General:

1. Prior to the commencement of any excavation or digging, the Contractor shall verify all underground utilities with the regional utility locator. Provide prior notice to the locator before excavations. Contact information for most regional utility locaters can be found at the following website (https://call811.com/) or by calling 811.
2. The Contractor shall do all excavating, filling, backfilling and compacting associated with the work.

B. Excavation:

1. Make all excavations to accurate, solid, undisturbed earth, and to proper dimensions.
2. Where excavations are made in error below foundations, concrete of same strength as specified for the foundations or thoroughly compacted sand-gravel fill, as determined by the Architect/Engineer, shall be placed in such excess excavations. Place thoroughly compacted, clean, stable fill in excess excavations under slabs on grade, at the Contractor's expense.
3. Trim bottom and sides of excavations to grades required for foundations.
4. Protect excavations against frost and freezing.
5. Take care in excavating not to damage surrounding structures, equipment, or buried utilities. Do not undermine footing or foundation.
6. Perform all trenching in a manner to prevent cave-ins and risk to workers.
7. Where original surface is pavement or concrete, the surface shall be saw cut to provide clean edges and assist in the surface restoration.
8. Where satisfactory bearing soil for foundations is not found at the indicated levels, the Architect/Engineer or their representative shall be notified immediately, and no further work shall be done until further instructions are given by the Architect/Engineer or their representative.

C. Dewatering:

1. Contractor shall furnish, install, operate, and remove all dewatering pumps and pipes needed to keep trenches and pits free of water.

D. Underground Obstructions:

1. Known underground piping, foundations, and other obstructions in the vicinity of construction are shown on the drawings. Use great care in making installations near underground obstruction.
2. If objects not shown on the drawings are encountered, remove, relocate, or perform extra work as directed by the Architect/Engineer.

E. Fill and Backfilling:

1. Utilities Bedding: Lay underground utilities on minimum of 6"sand bedding or CA6 crushed stone. Compact bedding under utilities smooth, with no sharp edges protruding, to protect the utilities from puncture. Shape bedding to provide continuous support for bells, joints, and barrels of utilities and for joints and fittings.
2. Envelope around utilities to 6" above utilities: Place and compact sand or CA6 to a height of 6" over utilities in 6" layers. Each layer shall be placed, then carefully and uniformly tamped, to eliminate lateral or vertical displacement. After connection joints are made, any misalignment can be corrected by tamping backfill around the utilities.
3. Backfill from 6" above utilities to earthen grade: Place all backfill materials above the utilities in uniform layers not exceeding 6" deep. Each layer shall be placed, then carefully and uniformly tamped, to eliminate lateral or vertical displacement.
4. Backfill from 6" above utilities to below slabs or paved area: Where the fill and backfill will ultimately be under a building, floor or paving, each layer of backfill materials shall be compacted to 95% of the maximum density determined by AASHTO Designation T 99 or ASTM Designation D 698. Moisture content of soil at time of compaction shall not exceed plus or minus 2% of optimum moisture content determined by AASHTO T 99 or ASTM D 698 test.
5. Backfill Materials: Native soil materials may be used as backfill if approved by the Geotechnical Engineer. Backfill material shall be free of rock or gravel larger than 3" in any dimension and shall be free of debris, waste, frozen materials, vegetation, high void content, and other deleterious materials. Water shall not be permitted to rise in unbackfilled trenches.
6. Dispose of excess excavated earth as directed.
7. Backfill all trenches and excavations immediately after installing utilities or removal of forms, unless other protection is provided.
8. Around piers and isolated foundations and structures, backfill and fill shall be placed and consolidated simultaneously on all sides to prevent wedge action and displacement. Fill and backfill materials shall be spread in 6 inch uniform horizontal layers with each layer compacted separately to required density.

F. Surface Restoration:

1. Where trenches are cut through existing graded, planted, or landscaped areas, the areas shall be restored to the original condition. Replace all planting removed or damaged to its original condition. A minimum of 6 inches of topsoil shall be applied where disturbed areas are to be seeded or sodded.
2. Concrete or asphalt type pavement, seal coat, rock, gravel or earth surfaces removed or damaged shall be replaced with comparable materials and restored to original condition.

3.3 ARCHITECT/ENGINEER OBSERVATION OF WORK

A. The Contractor shall provide seven (7) calendar days' notice to the Architect/Engineer prior to:

1. Placing fill over underground and underslab utilities.
2. Covering exterior walls, interior partitions and chases.
3. Installing hard or suspended ceilings and soffits.

B. The Architect/Engineer will have the opportunity to review the installation and provide a written report noting deficiencies requiring correction. The Contractor's schedule shall account for these reviews and show them as line items in the approved schedule.

C. Above-Ceiling Final Observation

1. All work above the ceilings must be complete prior to the Architect/Engineer's review. This includes, but is not limited to:

   a. Pipe wall penetrations are sealed.
   b. Pipe identification is installed.
   c. Branch piping in the location of sprinklers shall be dropped to the ceiling.

2. In order to prevent the Above-Ceiling Final Observation from occurring too early, the Contractor shall review the status of the work and certify, in writing, that the work is ready for the Above-Ceiling Final Observation.
3. It is understood that if the Architect/Engineer finds the ceilings have been installed prior to this review and prior to 7 days elapsing, the Architect/Engineer may not recommend further payments to the contractor until such time as full access has been provided.

3.4 PROJECT CLOSEOUT

A. The following paragraphs supplement the requirements of Division 01.

B. Final Jobsite Observation:

1. In order to prevent the Final Jobsite Observation from occurring too early, the Contractor is required to review the completion status of the project and certify that the job is ready for the final jobsite observation.
2. Attached to the end of this section is a typical list of items that represent the degree of job completeness expected prior to requesting a review.
3. Upon Contractor certification that the project is complete and ready for a final observation, the Contractor shall sign the attached certification and return it to the Architect/Engineer so that the final observation can be scheduled.
4. It is understood that if the Architect/Engineer finds the job not ready for the final observation and that additional trips and observations are required to bring the project to completion, the costs incurred by the Architect/Engineer's additional time and expenses will be deducted from the Contractor's contract retainage prior to final payment at the completion of the job.

C. Before final payment is authorized, this Contractor must submit the following:

1. Operation and maintenance manuals with copies of approved shop drawings.
2. Record documents including marked-up or reproducible drawings and specifications.
3. A report documenting the instructions given to the Owner's representatives complete with the number of hours spent in the instruction. The report shall bear the signature of an authorized agent of This Contractor and shall be signed by the Owner's representatives.
4. Inspection report by the State Fire Marshal of the fire protection system.
5. Start-up reports on all equipment requiring a factory installation inspection or start-up.
6. Provide spare parts, maintenance, and extra materials in quantities specified in individual specification sections. Deliver to project site and place in location as directed; receipt by Architect/Engineer required prior to final payment approval.

3.5 OPERATION AND MAINTENANCE MANUALS

A. General:

1. Provide an electronic copy of the O&M manuals as described below for Architect/Engineer's review and approval. The electronic copy shall be corrected as required to address the Architect/Engineer's comments. Once corrected, electronic copies and paper copies shall be distributed as directed by the Architect/Engineer.
2. Approved O&M manuals shall be completed and in the Owner's possession prior to Owner's acceptance and at least 10 days prior to instruction of operating personnel.

B. Electronic Submittal Procedures:

1. Distribution: Email the O&M manual as attachments to all parties designated by the Architect/Engineer.
2. Transmittals: Each submittal shall include an individual electronic letter of transmittal.
3. Format: Electronic submittals shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Submittals that are not legible will be rejected. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.
4. File Names: Electronic submittal file names shall include the relevant specification section number followed by a description of the item submitted, as follows. Where possible, include the transmittal as the first page of the PDF instead of using multiple electronic files.

    a. O&M file name: O&M.div21.contractor.YYYYMMDD
    b. Transmittal file name: O&Mtransmittal.div21.contractor.YYYYMMDD

5. File Size: Files shall be transmitted via a pre-approved method. Larger files may require an alternative transfer method, which shall also be pre-approved.
6. Provide the Owner with an approved copy of the O&M manual on compact discs (CD), digital video discs (DVD), or flash drives with a permanently affixed label, printed with the title "Operation and Maintenance Instructions", title of the project and subject matter of disc/flash drive when multiple disc/flash drives are required.
7. All text shall be searchable.
8. Bookmarks shall be used, dividing information first by specification section, then systems, major equipment and finally individual items. All bookmark titles shall include the nomenclature used in the construction documents and shall be an active link to the first page of the section being referenced.

C. Operation and Maintenance Instructions shall include:

1. Title Page: Include title page with project title, Architect, Engineer, Contractor, all subcontractors, and major equipment suppliers, with addresses, telephone numbers, website addresses, email addresses and point of contacts. Website URLs and email addresses shall be active links in the electronic submittal.
2. Table of Contents: Include a table of contents describing specification section, systems, major equipment, and individual items.

3. Copies of all final approved shop drawings and submittals. Include Architect's/Engineer's shop drawing review comments. Insert the individual shop drawing directly after the Operation and Maintenance information for the item(s) in the review form.
4. Copy of final approved test and balance reports.
5. Copies of all factory inspections and/or equipment startup reports.
6. Copies of warranties.
7. Schematic electrical power/controls wiring diagrams of the equipment that have been updated for field conditions. Field wiring shall have label numbers to match drawings.
8. Dimensional drawings of equipment.
9. Capacities and utility consumption of equipment.
10. Detailed parts lists with lists of suppliers.
11. Operating procedures for each system.
12. Maintenance schedule and procedures. Include a chart listing maintenance requirements and frequency.
13. Repair procedures for major components.
14. List of lubricants in all equipment and recommended frequency of lubrication.
15. Instruction books, cards, and manuals furnished with the equipment.

3.6 INSTRUCTING THE OWNER'S REPRESENTATIVES

A. Adequately instruct the Owner's designated representatives in the maintenance, care, and operation of all systems installed under this contract.

B. Provide verbal and written instructions to the Owner's representatives by FACTORY PERSONNEL in the care, maintenance, and operation of the equipment and systems.

C. The Owner has the option to make a video recording of all instructions. Coordinate schedule of instructions to facilitate this recording.

D. The instructions shall include:

1. Explanation of all system flow diagrams.
2. Maintenance of equipment.
3. Start-up procedures for all major equipment.
4. Explanation of seasonal system changes.
5. Description of emergency system operation.

E. Notify the Architect/Engineer of the time and place for the verbal instructions to be given to the Owner's representative so a representative can attend if desired.

F. Minimum hours of instruction for each item shall be:

1. Sprinkler System(s) - 8 hours.

G. The Contractor shall prepare a detailed, written training agenda and submit it to the Architect/Engineer a minimum of four weeks prior to the formal training for approval. The written agenda shall include specific training points within the items described above. For example: how to adjust setpoints, troubleshooting, proper start-up, proper shut-down, seasonal changes, draining, venting, changing filters, changing belts, etc. Failure to provide and follow an approved training agenda may result in additional training required at the expense of the Contractor.

H. Operating Instructions:

1. Contractor is responsible for all instructions to the Owner's representatives for the fire protection and control systems.
2. If the Contractor does not have staff that can adequately provide the required instructions the Contractor shall include in the bid an adequate amount to reimburse the Owner for the Architect/Engineer to perform these services.

3.7 SYSTEM STARTING AND ADJUSTING

A. The fire protection systems shall be complete and operating. System startup, testing, adjusting, and balancing to obtain satisfactory system performance is the responsibility of the Contractor. This includes calibration and adjustments of all controls, noise level adjustments and final comfort adjustments as required.

B. Complete all manufacturer-recommended startup procedures and checklists to verify proper motor rotation, electrical power voltage is within equipment limitations, equipment controls maintain pressures and temperatures within acceptable ranges, all filters and protective guards are in-place, acceptable access is provided for maintenance and servicing, and equipment operation does not pose a danger to personnel or property.

C. All operating conditions and control sequences shall be tested during the start-up period. Test all interlocks, safety shutdowns, controls, and alarms.

D. The Contractor, subcontractors, and equipment suppliers shall have skilled technicians to ensure that all systems perform properly. If the Architect/Engineer is requested to visit the job site for trouble shooting, assisting in start-up, obtaining satisfactory equipment operation, resolving installation and/or workmanship problems, equipment substitution issues or unsatisfactory system performance, including call backs during the warranty period, through no fault of the design; the Contractor shall reimburse the Owner on a time and materials basis for services rendered at the Architect/Engineer's standard hourly rates in effect when the services are requested. The Contractor shall pay the Owner for services required that are product, installation or workmanship related. Payment is due within 30 days after services are rendered.

3.8 RECORD DOCUMENTS

A. The following paragraphs supplement Division 01 requirements.

B. Maintain at the job site a separate and complete set of fire protection drawings and specifications with all changes made to the systems clearly and permanently marked in complete detail.

C. Mark drawings to indicate revisions to piping size and location, both exterior and interior; including locations of other control devices, and other units requiring periodic maintenance or repair; actual equipment locations, dimensioned from column lines; actual inverts and locations of underground piping; concealed equipment, dimensioned from column lines; mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located; Change Orders; concealed control system devices.

D. Before completion of the project, a set of reproducible fire protection drawings will be given to the Contractor for transfer of all as-built conditions from the paper set maintained at the job site. All marks on reproducibles shall be clear and permanent.

E. Mark specifications to show approved substitutions; Change Orders, and actual equipment and materials used.

F. Record changes daily and keep the marked drawings available for the Architect/Engineer's examination at any normal work time.

G. Upon completing the job, and before final payment is made, give the marked-up drawings to the Architect/Engineer.

3.9 PAINTING

A. This Contractor shall paint the following items:

1. All piping in mechanical room

B. Paint all equipment that is marred or damaged prior to the Owner's acceptance. Paint and color shall match original equipment paint and shall be obtained from the equipment supplier if available.

C. Equipment in finished areas that will be painted to match the room decor will be painted by others. Should this Contractor install equipment in a finished area after the area has been painted, the Contractor shall have the equipment and all its supports, hangers, etc., painted to match the room decor.

D. Equipment cabinets, casings, covers, metal jackets, etc., in equipment rooms or concealed spaces, shall be furnished in standard or prime finish, free from scratches, abrasions, chips, etc.

E. Equipment in occupied spaces, or if standard to the unit, shall have a baked primer with baked enamel finish coat free from scratches, abrasions, chips, etc. If color option is specified or is standard to the unit, this Contractor shall, before ordering, verify with the Architect/Engineer the color preference and furnish this color.

F. Paint all equipment in unfinished areas such as boiler room, mechanical spaces, storage room, etc., furnished by this Contractor. Equipment furnished with a factory coat of paint and enamel need not be painted, provided the factory applied finish is not marred or spattered. If so, equipment shall be refinished with the same paint as was factory applied.

G. Paint all outdoor uninsulated steel piping the color selected by Owner or Architect/Engineer.

H. After surfaces have been thoroughly cleaned and are free of oil, dirt, and other foreign matter, paint all pipes and equipment with the following:

1. Bare Metal Surfaces: Apply one coat of primer suitable for the metal being painted. Finish with two coats of Alkyd base enamel paint.
2. Color of paint shall be as follows:

a. All piping in mechanical room:

1) Fire Protection: Red pipe/white letters

3.10 ADJUST AND CLEAN

A. Thoroughly clean all equipment and systems prior to the Owner's final acceptance of the project. Clean all foreign paint, grease, oil, dirt, labels, stickers, and other foreign material from all equipment.

B. Clean all areas where moisture is present. Immediately report any mold, biological growth, or water damage.

C. Remove all rust, scale, dirt, oils, stickers and thoroughly clean exterior of all exposed piping, hangers, and accessories.

D. Remove all rubbish, debris, etc., accumulated during construction from the premises.

3.11 SPECIAL REQUIREMENTS

A. Contractor shall coordinate the installation of all equipment, valves, etc., with other trades to maintain clear access area for servicing.

B. All equipment shall be installed in such a way to maximize access to parts needing service or maintenance. Review the final field location, placement, and orientation of equipment with the Owner's designated representative prior to setting equipment.

C. Installation of equipment or devices without regard to coordination of access requirements and confirmation with the Owner's designated representative will result in removal and reinstallation of the equipment at the Contractor's expense.

3.12 IAQ MAINTENANCE FOR OCCUPIED FACILITIES UNDER CONSTRUCTION

A. Contractors shall make all reasonable efforts to prevent construction activities from affecting the air quality of the occupied areas of the building or outdoor areas near the building. These measures shall include, but not be limited to:

1. All contractors shall endeavor to minimize the amount of contaminants generated during construction. Methods to be employed shall include, but not be limited to:

   a. Minimizing the amount of dust generated.
   b. Reducing solvent fumes and VOC emissions.
   c. Maintain good housekeeping practices, including sweeping and periodic dust and debris removal. There should be no visible haze in the air.

2. Request that the Owner designate an IAQ representative.
3. Review and receive approval from the Owner's IAQ representative for all IAQ-related construction activities and negative pressure containment plans.
4. Inform the IAQ representative of all conditions that could adversely impact IAQ, including operations that will produce higher than normal dust production or odors.
5. Schedule activities that may cause IAQ conditions that are not acceptable to the Owner's IAQ representative during unoccupied periods.
6. Request copies of and follow all of the Owner's IAQ and infection control policies.
7. Unless no other access is possible, the entrance to construction site shall not be through the existing facility.
8. To minimize growth of infectious organisms, do not permit damp areas in or near the construction area to remain for over 24 hours.
9. In addition to the criteria above, provide measures as recommended in the SMACNA "IAQ Guidelines for Occupied Buildings Under Construction".

END OF SECTION 21 05 00

SECTION 21 05 05 - FIRE SUPPRESSION DEMOLITION FOR REMODELING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Fire Suppression Demolition.

B. Cutting and Patching.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Materials and equipment shall be as specified in individual Sections.

PART 3 - EXECUTION

3.1 EXAMINATION

A. THE DRAWINGS ARE INTENDED TO INDICATE THE GENERAL SCOPE OF WORK AND DO NOT SHOW EVERY PIPE, DUCT, OR PIECE OF EQUIPMENT THAT MUST BE REMOVED. THE CONTRACTOR SHALL VISIT THE SITE AND VERIFY CONDITIONS PRIOR TO SUBMITTING A BID.

B. Where walls, ceilings, etc., are shown as being removed on general drawings, the Contractor shall remove all mechanical equipment, devices, fixtures, piping, ducts, systems, etc., from the removed area.

C. Where ceilings, walls, partitions, etc., are temporarily removed and replaced by others, This Contractor shall remove, store, and replace equipment, devices, fixtures, pipes, ducts, systems, etc.

D. Verify that abandoned utilities serve only abandoned equipment or facilities. Extend services to facilities or equipment that shall remain in operation following demolition.

E. Coordinate work with all other Contractors and the Owner. Schedule removal of equipment to avoid conflicts.

F. This Contractor shall verify all existing equipment sizes and capacities where equipment is scheduled to be replaced or modified, prior to ordering new equipment.

G. Bid submittal shall mean the Contractor has visited the project site and verified existing conditions and scope of work.

3.2 PREPARATION

A. Disconnect fire protection systems in walls, floors, and ceilings scheduled for removal.

B. Provide temporary connections to maintain existing systems in service during construction. When work must be performed on operating equipment, use personnel experienced in such operations.

3.3 DEMOLITION AND EXTENSION OF EXISTING MECHANICAL WORK

A. Remove, relocate, and extend existing installations to accommodate new construction.

B. Remove abandoned piping to source of supply and/or main lines.

C. Remove exposed abandoned pipes, including abandoned pipes above accessible ceilings. Cut pipes above ceilings, below floors and behind walls. Cap remaining lines. Repair building construction to match original. Remove all clamps, hangers, supports, etc. associated with pipe and duct removal.

D. Disconnect and remove mechanical devices and equipment serving equipment that has been removed.

E. Repair adjacent construction and finishes damaged during demolition and extension work.

F. Maintain access to existing mechanical installations which remain. Modify installation or provide access panels as appropriate.

G. Extend existing installations using materials and methods compatible with existing installations, or as specified.

3.4 CUTTING AND PATCHING

A. This Contractor is responsible for all penetrations of existing construction required to complete the work of this project. Refer to Section 21 05 29 for additional requirements.

B. Penetrations in existing construction should be reviewed carefully prior to proceeding with any work.

C. Penetrations shall be neat and clean with smooth and/or finished edges. Core drill where possible for clean opening.

D. Repair existing construction as required after penetration is complete to restore to original condition. Use similar materials and match adjacent construction unless otherwise noted or agreed to by the Architect/Engineer prior to start of work.

E. Floor slab is post-tensioned. All penetrations shall be x-rayed prior to cutting and/or drilling to avoid any tension cables or utilities encased in floor construction.

F. Floor slabs may contain conduit systems. This Contractor is responsible for taking any measures required to ensure no conduits or other services are damaged. This includes x-ray or similar non-destructive means.

G. This Contractor is responsible for <u>all</u> costs incurred in repair, relocations, or replacement of any cables, conduits, or other services if damaged without proper investigation.

3.5 CLEANING AND REPAIR

A. Clean and repair existing materials and equipment which remain or are to be reused.

B. Clean all systems adjacent to project which are affected by the dust and debris caused by this construction.

C. FIRE PROTECTION ITEMS REMOVED AND NOT RELOCATED REMAIN THE PROPERTY OF THE OWNER. CONTRACTOR SHALL PLACE ITEMS RETAINED BY THE OWNER IN A LOCATION COORDINATED WITH THE OWNER. THE CONTRACTOR SHALL DISPOSE OF MATERIAL THE OWNER DOES NOT WANT TO REUSE OR RETAIN FOR MAINTENANCE PURPOSES.

3.6 SPECIAL REQUIREMENTS

A. Install temporary filter media over outside air intakes which are within 100 feet of the limits of construction or as noted on the drawings. This Contractor shall complete any cleaning required for existing systems which are affected by construction dust and debris.

B. Review locations of all new penetrations in existing floor slabs or walls. Determine construction type and review for possible interferences. Bring all concerns to the attention of the Architect/Engineer before proceeding.

END OF SECTION 21 05 05

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SECTION 21 05 13 - MOTORS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Single Phase and Three Phase Electric Motors.

1.2 SUBMITTALS

A. Submit shop drawings under provisions of Section 21 05 00. Include nominal efficiency and power factor for all premium efficiency motors. Efficiencies must meet or exceed the nominal energy efficiency levels presented below.

B. Submit shop drawings for <u>all</u> three phase motors.

C. Submit motor data with equipment when motor is installed by the manufacturer at the factory.

D. Submit shaft grounding rings or brushes or ceramic bearings for all motors as required.

1.3 DELIVERY, STORAGE, AND HANDLING

A. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weatherproof coverings. For extended outdoor storage, follow manufacturer's recommendations for equipment and motor.

1.4 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data including assembly drawings, bearing data including replacement sizes, and lubrication instructions.

1.5 QUALIFICATIONS

A. Manufacturer: Company specializing in the manufacture of commercial and industrial motors and accessories, with a minimum of three years documented manufacturing experience.

PART 2 - PRODUCTS

2.1 GENERAL CONSTRUCTION AND REQUIREMENTS

A. Refer to the drawings for required electrical characteristics. Voltage is generally specified and scheduled as distribution voltage. Motor submittals may be based on utilization voltage if it corresponds to the correct distribution voltage.

Distribution/Nominal Voltage	Utilization Voltage
120	115
208	200
240	230
277	265
480	460

B. Design motors for continuous operation in 40°C environment, and for temperature rise in accordance with ANSI/NEMA MG 1 limits for insulation class, service factor, and motor enclosure type.

C. Explosion-Proof Motors: UL listed and labeled for the hazard classification shown on the drawing, with over-temperature protection.

D. Visible Nameplate: Indicating horsepower, voltage, phase, hertz, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, service factor, power factor, insulation class.

E. Electrical Connection: Boxes, threaded for conduit. For fractional horsepower motors where connection is made directly, provide conduit connection in end frame.

F. Unless otherwise indicated, motors 3/4 HP and smaller shall be single phase, 60 hertz, open drip-proof or totally enclosed fan-cooled type.

G. Unless otherwise indicated, motors 1 HP and larger shall be three phase, 60 hertz, squirrel cage type, NEMA Design Code B (low current in-rush, normal starting torque), open drip-proof or totally enclosed fan-cooled type.

H. Each contractor shall set all motors furnished by the contractor.

I. All motors shall have a minimum service factor of 1.15.

J. All motors shall have ball or roller bearings with a minimum L-10 fatigue life of 150,000 hours in direct-coupled applications and 50,000 hours for belted applications. Belted rating shall be based on radial loads and pulley sizes called out in NEMA MG1-14.43.

K. Aluminum end housings are not permitted on motors 15 HP (or larger.)

L. Motor Driven Equipment:

1. No equipment shall be selected or operate above 90% of its motor nameplate rating. Motor size may not be increased to compensate for equipment with efficiency lower than that specified.
2. If a larger motor than specified is required on equipment, the contractor supplying the equipment is responsible for all additional costs due to larger starters, wiring, etc.

2.2 PREMIUM EFFICIENCY MOTORS (INCLUDING MOST 3-PHASE GENERAL PURPOSE MOTORS)

A. All motors, unless exempted by EPAct legislation that became federal law on December 19, 2010, shall comply with the efficiencies listed in that standard, which are reprinted below. These match the 2010 NEMA premium efficiency ratings. All ratings listed are nominal full load efficiencies, verified in accordance with IEEE Standard 112, Test Method B. Average expected (not guaranteed minimum) power factors shall also be at least the following:

	Open Drip-Proof			Totally Enclosed Fan Cooled		
HP	1200 rpm	1800 rpm	3600 rpm	1200 rpm	1800 rpm	3600 rpm
1.0	82.5	85.5	77.0	82.5	85.5	77.0
1.5	86.5	86.5	84.0	87.5	86.5	84.0
2.0	87.5	86.5	85.5	88.5	86.5	85.5
3.0	88.5	89.5	85.5	89.5	89.5	86.5
5.0	89.5	89.5	86.5	89.5	89.5	88.5
7.5	90.2	91.0	88.5	91.0	91.7	89.5
10.0	91.7	91.7	89.5	91.0	91.7	90.2
15.0	91.7	93.0	90.2	91.7	92.4	91.0
20.0	92.4	93.0	91.0	91.7	93.0	91.0
25.0	93.0	93.6	91.7	93.0	93.6	91.7

30.0	93.6	94.1	91.7	93.0	93.6	91.7
40.0	94.1	94.1	92.4	94.1	94.1	92.4
50.0	94.1	94.5	93.0	94.1	94.5	93.0
60.0	94.5	95.0	93.6	94.5	95.0	93.6
75.0	94.5	95.0	93.6	94.5	95.4	93.6
100.0	95.0	95.4	93.6	95.0	95.4	94.1
125.0	95.0	95.4	94.1	95.0	95.4	95.0
150.0	95.4	95.8	94.1	95.8	95.8	95.0
200.0	95.4	95.8	95.0	95.8	96.2	95.4
250.0	95.4	95.8	95.0	95.8	96.2	95.8
300.0	95.4	95.8	95.4	95.8	96.2	95.8
350.0	95.4	95.8	95.4	95.8	96.2	95.8
400.0	95.8	95.8	95.8	95.8	96.2	95.8
450.0	96.2	96.2	95.8	95.8	96.2	95.8
500.0	96.2	96.2	95.8	95.8	96.2	95.8

B. Motor nameplate shall be noted with the above ratings.

2.3 MOTORS ON VARIABLE FREQUENCY DRIVES

A. All motors driven by VFDs shall be premium efficiency type.

B. Motors shall be designed for use with VFDs in variable torque applications with 1.15 service factor. Motors shall not be equipped with auxiliary blowers.

C. Motors driven by VFDs shall have Class F or H insulation and be designated by the motor manufacturer to be suitable for inverter duty service in accordance with NEMA MG 1 Section IV, "Performance Standards Applying to All Machines," Part 31 "Definite-Purpose Inverter-Fed Polyphase Motors.

D. All 480 volt motors driven by VFDs shall be provided with shaft grounding rings or grounding brushes or ceramic bearings as a means to protect bearings from adverse shaft currents.

1. Providing grounding rings internal to the motor housing is an acceptable solution, provided the motor is affixed with a label clearly indicating the presence of a grounding assembly. The grounding ring shall be listed for 40,000 hours of motor service and shall be accessible via the drive endplate.
2. Motor shafts 2" and larger require shaft grounding on the drive end and the non-drive end. This Contractor shall ensure (via field observation and measurement) that the shaft is effectively grounded upon startup.
3. In addition to 480 volt motors driven by VFDs, the following critical motors shall also be equipped with shaft grounding rings or brushes or ceramic bearings:

    a. Jockey Pump.

PART 3 - EXECUTION

3.1 INSTALLATION

A. All rotating shafts and/or equipment shall be completely guarded from all contact. Partial guards and/or guards that do not meet all applicable OSHA standards are not acceptable. Contractor is responsible for providing this guarding if it is not provided with the equipment supplied.

B. For flexible coupled drive motors, mount coupling to the shafts in accordance with the coupling manufacturer's recommendations. Align shafts to manufacturer's requirements or within 0.002 inch per inch diameter of coupling hub.

C. For belt drive motors, mount sheaves on the appropriate shafts per manufacturer's instructions. Use a straight edge to check alignment of the sheaves. Reposition sheaves as necessary so the straight edge contacts both sheave faces squarely. After sheaves are aligned, loosen the adjustable motor base so the belt(s) can be added, and tighten the base so the belt tension is in accordance with the drive manufacturer's recommendations. Frequently check belt tension and adjust if necessary during the first day of operation and again after 80 hours of operation.

END OF SECTION 21 05 13

SECTION 21 05 29 - FIRE SUPPRESSION SUPPORTS AND ANCHORS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Hangers, Supports, and Associated Anchors.

B. Equipment Bases and Supports.

C. Sleeves and Seals.

D. Flashing and Sealing of Equipment and Pipe Stacks.

E. Cutting of Openings.

F. Escutcheon Plates and Trim.

1.2 QUALITY ASSURANCE

A. Support Sprinkler Piping in conformance with NFPA 13.

B. Support Standpipes in conformance with NFPA 14.

1.3 WORK FURNISHED BUT INSTALLED UNDER OTHER SECTIONS

A. Furnish sleeves and hanger inserts to General Contractor for placement into formwork.

PART 2 - PRODUCTS

2.1 SEISMIC RESTRAINTS

A. Refer to Section 21 05 50 for additional requirements for seismic restraints.

2.2 HANGER RODS

A. Hanger rods for single rod hangers supporting steel, copper, and CPVC piping shall conform to the following:

Pipe Size	Rod Size
4" and smaller	3/8"
5" 6", and 8"	1/2"

B. Hanger rods and accessories used in mechanical spaces or otherwise dry areas shall have ASTM B633 electro-plated zinc finish.

C. All hanger rods, nuts, washers, clevises, etc., in damp areas shall have ASTM A123 hot-dip galvanized finish applied after fabrication. This applies to the following areas:

2.3 PIPE HANGERS AND SUPPORTS

A. General:

1. All pipe hangers, clamps, and supports shall conform to Manufacturers Standardization Society MSS-SP-58, 69, 89, and 127 (where applicable).

B. Vertical Supports:

1. Support and laterally brace vertical pipes at every floor level in multi-story structures, and more frequently when required by applicable codes, but never at intervals over 15 feet. Support vertical pipes with riser clamps installed below hubs, couplings or lugs. Provide sufficient flexibility to accommodate expansion and contraction without compromising fire barrier penetrations and other fixed takeoff locations.

   a. Products:

      1) Anvil Fig.
      2) CT121
      3) Cooper/B-Line Fig.
      4) B3373CT
      5) Erico Model 510
      6) Nibco/Tolco Fib. 82

2. Wall supports shall be used where vertical height of structure exceeds minimum spacing requirements. Install wall supports at same spacing as hangers or strut supports along vertical length of pipe runs.
3. Masonry Anchors: Fasten to concrete masonry units with expansion anchors or self-tapping masonry screws. For expansion anchors into hollow concrete block, use sleeve-type anchors designed for the specific application. Do not fasten in masonry joints. Do not use powder actuated fasteners, wooden plugs, or plastic inserts.

C. Hangers and Clamps:

1. Hangers in direct contact with bare copper pipe shall include plastic pipe insert similar to Unistrut Cush-A-Clamp, Hydra-Zorb, Erico Cushion Clamp or Cooper Vibra-Clamp.
2. Unless otherwise indicated, hangers shall be as follows:

   a. Clevis Type: Service: Bare Metal Pipe

      1) Products: Bare Steel or Insulated Pipe

         a) Anvil Fig. 260
         b) Cooper/B-Line Fig. 3100
         c) Erico Model 400
         d) Nibco/Tolco Fig. 1.

      2) Products: Bare Copper Pipe

         a) Anvil Fig. CT65
         b) Cooper/B-Line Fig. B3104CT
         c) Erico Model 402
         d) Nibco/Tolco Fig. 81.

   b. Adjustable Swivel Ring Type: Service: Bare Metal Pipe - 4 inches and Smaller

      1) Products: Bare Steel Pipe

         a) Anvil Fig. 69

b) Cooper/B-Line Fig. B3170NF
c) Erico Model FCN
d) Nibco/Tolco Fig. 200.

2) Products: Bare Copper Pipe

a) Anvil Fig. CT69
b) Cooper/B-Line Fig. B170CT
c) Nibco/Tolco Fig. 202.

3. Support may be fabricated from U-channel strut or similar shapes. Piping less than 4" in diameter shall be secured to strut with clamps of proper design and capacity as required to maintain spacing and alignment. Strut shall be independently supported from hanger drops or building structure. Size and support shall be per manufacturer's installation requirements for structural support of piping. Clamps shall not interrupt piping insulation.
4. Strut used in mechanical spaces or otherwise dry areas shall have ASTM B633 electro-plated zinc finish.
5. Strut used in damp areas listed in hanger rods shall have ASTM A123 hot-dip galvanized finish applied after fabrication.
6. Unless otherwise indicated, pipe supports for use with struts shall be as follows:

a. Clamp Type: Service: Bare Metal Pipe, Rigid Plastic Pipe

1) Clamps in direct contact with copper pipe shall include plastic pipe insert similar to Unistrut Cush-A-Clamp, Hydra-Zorb, Erico Cushion Clamp or Cooper Vibra-Clamp.
2) Pipes subject to expansion and contraction shall have clamps slightly oversized to allow limited pipe movement.
3) Products: Bare Steel, Plastic or Insulated Pipe

a) Unistrut Fig. P1100 or P2500
b) Cooper/B-Line Fig. B2000 or B2400
c) Nibco/Tolco Fig. A-14 or 2STR.

4) Products: Bare Copper Pipe

a) Cooper/B-Line; Fig. BVT

D. Upper (Structural) Attachments:

1. Unless otherwise shown, upper attachments for hanger rods or support struts shall be as follows:

a. Steel Structure Clamps: C-Type Wide Flange Beam Clamps (for use on top and/or bottom of wide flanges. Not permitted for use with bar-joists.)

1) Products:

a) Anvil Fig. 92
b) Cooper/B-Line Fig. B3033/B3034
c) Erico Model 300
d) Nibco/Tolco 68.

b. Scissor Type Beam Clamps (for use with bar-joists and wide flange):

1) Products:

a) Anvil Fig. 228, 292
b) Cooper/B-Line Fig. B3054
c) Erico Model 360
d) Nibco/Tolco Fig. 329.

c. Concentrically Loaded Open Web Joist Hangers (for use with bar joists):

1) Products:

a) MCL. M1, M2 or M3

d. Concrete Inserts Single Rod Galvanized:

1) Products:

a) Anvil Fig. 282
b) Cooper/B-Line Fig. B3014
c) Erico Model 355
d) Nibco/Tolco Fig. 310

e. Concrete Inserts Continuous Strip Galvanized:

1) Products:

a) Unistrut Corp P3200 Series
b) Cooper/B-Line Fig. B22-J
c) Erico CONCT

f. Concrete Anchors: Fasten to concrete using cast-in or post-installed anchors designed per the requirements of Appendix D of ACI 318-11. Post-installed anchors shall be qualified for use in cracked concrete by ACI-355.2.
g. Masonry Anchors: Fasten to concrete masonry units with expansion anchors or self-tapping masonry screws. For expansion anchors into hollow concrete block, use sleeve-type anchors designed for the specific application. Do not fasten in masonry joints. Do not use powder actuated fasteners, wooden plugs, or plastic inserts.
h. Steel Structure Welding:

1) Unless otherwise noted, hangers, clips, and auxiliary support steel may be welded in lieu of bolting, clamping, or riveting to the building structural frame. Take adequate precautions during all welding operations for fire prevention and for protecting walls and ceilings from being damaged by smoke.

2.4 FOUNDATIONS, BASES, AND SUPPORTS

A. Basic Requirements:

1. Furnish and install foundations, bases, and supports (not specifically indicated on the Drawings or in the Specifications of either the General Construction or Mechanical work as provided by another Contractor) for mechanical equipment.
2. All concrete foundations, bases and supports, shall be reinforced. All steel bases and supports shall receive a prime coat of zinc chromate or red metal primer. After completion of work, give steel supports a final coat of gray enamel.

B. Concrete Bases (Housekeeping Pads):

1. Refer to Section 21 05 50 for additional requirements for concrete bases in seismic applications.
2. Unless shown otherwise on the drawings, concrete bases shall be nominal 4 inches thick and shall extend 3 inches on all sides of the equipment (6 inches larger than factory base).
3. Where a base is less than 12 inches from a wall, extend the base to the wall to prevent a "dirt-trap".
4. Concrete materials and workmanship required for the Contractor's work shall be provided by the Contractor. Materials and workmanship shall conform to the applicable standards of the Portland Cement Association. Reinforce with 6" x 6", W1.4-W1.4 welded wire fabric. Concrete shall withstand 3,000 pounds compression per square inch at 28 days.
5. Equipment requiring bases is as follows:

a. Fire Pump

C. Roof Pipe Supports:

1. Provide pre-fabricated roof pipe supports for all piping installed on the roof.
2. Support shall guide and align pipe while permitting longitudinal expansion.
3. The base shall be rounded to prevent damage to the roof, and drainage holes shall prevent ponding of water in the support.
4. Support shall be UV, corrosion and freeze/thaw resistant.
5. Support shall include orange paint, reflective safety orange accents or similar markings for increased visibility.
6. The strut system shall have galvanized aluminum PVC coated powder coated finish.

    a. Products:

        1) Anvil International HBS-Base Series
        2) Cooper B-Line Dura-Blok
        3) Erico Caddy Pyramid 50,150, 300, or 600 (to match load)
        4) Miro Industries 1.5, 3-R, 4-R or 5-R (to match pipe).

D. Supports:

1. Provide sufficient clips, inserts, hangers, racks, rods, and auxiliary steel to securely support all suspended material, equipment and conduit without sag.
2. Hang heavy equipment from concrete floors or ceilings with Architect-approved concrete inserts, furnished and installed by the Contractor whose work requires them, except where indicated otherwise.

E. Grout:

1. Grout shall be non-shrinking premixed (Master Builders Company "Embecco"), unless otherwise indicated on the drawings or approved by the Architect/Engineer.
2. Use Mix No. 1 for clearances of 1" or less, and Mix No. 2 for all larger clearances.
3. Grout under equipment bases, around pipes, at pipe sleeves, etc., and where shown on the drawings.

2.5 OPENINGS IN FLOORS, WALLS AND CEILINGS

A. Exact locations of all openings for the installation of materials shall be determined by the Contractor and given to the General Contractor for installation or construction as the structure is built.

B. Coordinate all openings with other Contractors.

C. Hire the proper tradesman and furnish all labor, material and equipment to cut openings in or through existing structures, or openings in new structures that were not installed, or additional openings. Repair all spalling and damage to the satisfaction of the Architect/Engineer. Make saw cuts before breaking out concrete to ensure even and uniform opening edges.

D. Said cutting shall be at the complete expense of each Contractor. Failure to coordinate openings with other Contractors shall not exempt the Contractor from providing openings at Contractor's expense.

E. Do not cut structural members without written approval of the Architect or Structural Engineer.

2.6 ROOF PENETRATIONS

A. Seal pipes penetrating single-ply roofs with conical stepped pipe flashings and stainless steel clamps equal to Portals Plus Pipe Boots. Material shall match roofing membrane.

2.7 PIPE SLEEVES AND LINTELS

A. Each Contractor shall provide pipe sleeves and lintels for all openings required for the Contractor's work in masonry walls and floors, unless specifically shown as being by others.

B. Fabricate all sleeves from standard weight black steel pipe or as indicated on the drawings. Provide continuous sleeve. Cut or split sleeves are not acceptable.

C. Fabricate all lintels for masonry walls from structural steel shapes or as indicated on the drawings. Have all lintels approved by the Architect or Structural Engineer.

D. Sleeves through the floors on exposed risers shall be flush with the ceiling, with planed squared ends extending 1" above the floor in unfinished areas, and flush with the floor in finished areas.

E. Sleeves shall not penetrate structural members or masonry walls without approval from the Structural Engineer. Sleeves shall then comply with the Engineer's design.

F. Openings through unexcavated floors and/or foundation walls below the floor shall have a smooth finish with sufficient annular space around material passing through opening so slight settling will not place stress on the material or building structure.

G. Install all sleeves concentric with pipes. Secure sleeves in concrete to wood forms. This Contractor is responsible for sleeves dislodged or moved when pouring concrete.

H. Where pipes rise through concrete floors that are on earthen grade, provide 3/4" resilient expansion joint material (e.g., foam, rubber, asphalt-coated fiber, bituminous-impregnated felt, or cork) wrapped around the pipe, the full depth of concrete, at the point of penetration. Secure to prevent shifting during concrete placement and finishing.

I. Size sleeves large enough to allow expansion and contraction movement. Provide continuous insulation wrapping.

J. Wall Seals ("Link-Seals"):

1. Where shown on the drawings, pipes passing through walls, ceilings, or floors shall have their annular space (sleeve or drilled hole - not tapered hole made with knockout plug) sealed by properly sized sealing elements consisting of a synthetic rubber material compounded to resist aging, ozone, sunlight, water and chemical action.
2. Sleeves, if used, shall be standard weight steel with primed finish and waterstop/anchor continuously welded to sleeve or thermoplastic with integral water seal and textured surface.
3. Sleeves shall be at least 2 pipe sizes larger than the pipes.
4. Pressure shall be maintained by stainless steel bolts and other parts. Pressure plates may be of composite material for Models S and OS.
5. Sealing element shall be as follows:

Model	Service	Element Material	Temperature Range
S	Standard (Stainless)	EPDM	-40°F to 250°F
T	Fire Seals (1 hour)	Silicone	-67°F to 400°F
FS	Fire Seals (3 hours)	Silicone	-67°F to 400°F
OS	Oil Resistant/Stainless	Nitrile	-40°F to 210°F

6. Manufacturers:

a. Thunderline Corporation "Link-Seals"
b. O-Z/Gedney Company
c. Calpico, Inc.
d. Innerlynx
e. Metraflex Company (cold service only).

2.8 ESCUTCHEON PLATES AND TRIM

A. Fit escutcheons to all insulated or uninsulated exposed pipes passing through walls, floors, or ceilings of finished rooms.

B. Escutcheons shall be heavy gauge, cold rolled steel, copper coated under a chromium plated finish, heavy spring clip, rigid hinge and latch.

C. Install galvanized steel (unless otherwise indicated) trim strip to cover vacant space and raw construction edges of all rectangular openings in finished rooms. This includes duct and pipe openings.

2.9 PIPE PENETRATIONS

A. Seal all pipe penetrations. Seal non-rated walls and floor penetrations with grout or caulk. Backing material may be used.

B. Seal fire rated wall and floor penetrations with fire seal system as specified.

2.10 PIPE ANCHORS

A. Provide all items needed to allow adequate expansion and contraction of all piping. All piping shall be supported, guided, aligned, and anchored as required.

B. Repair all piping leaks and associated damage. Pipes shall not rub on any part of the building.

2.11 FINISH

A. Prime coat exposed steel hangers and supports. Hangers and supports in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

PART 3 - EXECUTION

3.1 FIRE SUPPRESSION SUPPORTS AND ANCHORS

A. General Installation Requirements:

1. Install all items per manufacturer's instructions.
2. Coordinate the location and method of support of piping systems with all installations under other Divisions and Sections of the Specifications.
3. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.
4. Supports shall extend directly to building structure. Do not support piping from duct hangers. Do not allow lighting or ceiling supports to be hung from piping supports.

B. Supports Requirements:

1. Install roof pipe supports to resist wind movement per manufacturer's recommendations. Method of securing base to roof shall be compatible with roofing materials.
2. Where building structural steel is fireproofed, all hangers, clamps, auxiliary steel, etc., which attach to it shall be installed prior to application of fireproofing. Repair all fireproofing damaged during pipe installation.
3. Set all concrete inserts in place before pouring concrete.
4. Furnish, install and prime all auxiliary structural steel for support of piping systems that are not shown on the Drawings as being by others.

5. Install hangers and supports complete with lock nuts, clamps, rods, bolts, couplings, swivels, inserts and required accessories.
6. Hangers for horizontal piping shall have adequate means of vertical adjustment for alignment.

C. Pipe Requirements:

1. Support all piping and equipment, including valves, strainers, and other specialties and accessories to avoid objectionable or excessive stress, deflection, swaying, sagging or vibration in the piping or building structure during erection, cleaning, testing and normal operation of the systems.
2. Do not, however, restrain piping to cause it to snake or buckle between supports or to prevent proper movement due to expansion and contraction.
3. Support piping at equipment and valves so they can be disconnected and removed without further supporting the piping.
4. Piping shall not introduce strains or distortion to connected equipment.
5. Parallel horizontal pipes may be supported on trapeze hangers made of structural shapes and hanger rods; otherwise, pipes shall be supported with individual hangers.
6. Trapeze hangers may be used where ducts interfere with normal pipe hanging.
7. Provide additional supports where pipe changes direction, adjacent to flanged valves and strainers, at equipment connections and heavy fittings.
8. Provide at least one hanger adjacent to each joint in grooved end steel pipe with mechanical couplings.

D. Provided the installation complies with all loading requirements of truss and joist manufacturers, the following practices are acceptable:

1. Loads of 100 lbs or less may be attached anywhere along the top or bottom chords of trusses or joists with a minimum 3' spacing between loads.
2. Loads greater than 100 lbs. must be hung concentrically and may be hung from top or bottom chord, provided one of the following conditions is met:

a. The hanger is attached within 6" from a web/chord joint.
b. Additional L2x2x1/4 web reinforcement is installed per manufacturer's requirements.

3. It is prohibited to cantilever a load using an angle or other structural component that is attached to a truss or joist in such a fashion that a torsional force is applied to that structural member.
4. If conditions cannot be met, coordinate installation with truss or joist manufacturer and contact Architect/Engineer.

E. After piping and insulation installation are complete, cut hanger rods back at trapeze supports so they do not extend more than 3/4" below bottom face of lowest fastener and blunt any sharp edges.

F. Do not exceed 25 lbs. per hanger and a minimum spacing of 2'-0" on center when attaching to metal roof decking (limitation not required with concrete on metal deck). This 25 lbs. load and 2'-0" spacing include adjacent electrical and architectural items hanging from deck. If the hanger restrictions cannot be achieved, supplemental framing off steel framing will need to be added.

G. Do not exceed the manufacturer's recommended maximum load for any hanger or support.

H. Steel/Concrete Structure: Spacing of hangers shall in no case exceed the following:

1. Steel (All steel pipe unless otherwise noted):

a. Maximum Spacing:

1) 1-1/4" & under: 12'-0"
2) 1-1/2" & larger: 15'-0"

2. Steel (Schedule 40 lightweight alternative):

   a. Maximum Spacing:

      1) 3" & under: 12'-0"

I. Installation of hangers shall conform to MSS SP-58, 69, 89, and applicable NFPA standards.

END OF SECTION 21 05 29

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SECTION 21 05 48 - FIRE PROTECTION VIBRATION ISOLATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Bases.

B. Vibration Isolation.

C. Flexible Connectors.

1.2 SUBMITTALS

A. Submit shop drawings per Section 21 05 00 and the Vibration Isolation Submittal Form at the end of this section.

B. Vibration isolation submittals may be included with equipment being isolated, but must comply with this section.

C. Base submittals shall include equipment served, construction, coatings, weights, and dimensions.

D. Isolator submittals shall include:

1. Equipment served
2. Type of Isolator
3. Load in Pounds per Isolator
4. Recommended Maximum Load for Isolator
5. Spring Constants of Isolators (for Spring Isolators)
6. Load vs. Deflection Curves (for Neoprene Isolators)
7. Specified Deflection
8. Deflection to Solid (at least 150% of calculated deflection)
9. Loaded (Operating) Deflection
10. Free Height
11. Loaded Height
12. Kx/Ky (horizontal to vertical stiffness ratio - for spring isolators)
13. Materials and Coatings
14. Spring Diameters

E. Make separate calculations for each isolator on equipment where the load is not equally distributed.

F. Flexible connector shop drawings shall include overall face-to-face length and all specified properties.

G. Submit certification that equipment, accessories, and components will withstand seismic forces defined in Section 21 05 50. Include the following:

1. Basis for Certification: Indicate whether certification is based on actual test of assembled components or on calculation.

   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

PART 2 - PRODUCTS

2.1 BASIC CONSTRUCTION AND REQUIREMENTS

A. Vibration isolation for this project is subject to seismic restraint requirements of Section 21 05 50.

B. Vibration isolators shall have either known undeflected heights or other markings so deflection under load can be verified.

C. All isolators shall operate in the linear portion of their load versus deflection curve. The linear portion of the deflection curve of all spring isolators shall extend 50% beyond the calculated operating deflection (e.g., 3" for 2" calculated deflection). The point of 50% additional deflection shall not exceed the recommended load rating of the isolator.

D. The lateral to vertical stiffness ratio (Kx/Ky) of spring isolators shall be between 0.8 and 2.0.

E. All isolators shall be designed or treated for corrosion resistance. Steel bases shall be cleaned of welding slag and primed for interior use. Bolts, nuts and washers shall be zinc electroplated. All damage to coatings shall be field repaired with two coats of zinc rich coating.

F. Equip all mountings used with structural steel bases with height-saving brackets. Bottoms of the brackets shall be 1-1/2" to 2-1/2" above the floor or housekeeping pad, unless shown otherwise on the drawings. Steel bases shall have at least four points of support.

G. Provide motor slide rails for belt-driven equipment per Section 21 05 13.

H. All isolators shall have provision for leveling.

2.2 MOUNTINGS

A. Type M2:

1. Double deflection neoprene with minimum static deflection of 0.15" at calculated load and 0.35" at maximum rated load.
2. All metal shall be neoprene covered. Mounting shall have friction pads both top and bottom.
3. All units shall have bolt holes and be bolted down.
4. Use steel rails above the mountings to compensate for the overhang of equipment such as small vent sets and close coupled pumps.
5. Manufacturers:

   a. Mason Industries "ND" or "DNR"
   b. Amber/Booth "RVD"
   c. Kinetics "RD"
   d. Vibration Mountings and Controls "RD"
   e. Vibration Eliminator Co. "T22" or "T44"

B. Type M3:

1. Free standing, laterally stable spring isolators without housings and complete with 1/4" neoprene friction pads.
2. Units shall have bolt holes but need not be bolted down unless called for or needed to prevent movement. If bolted down, prevent short circuiting with neoprene bushings and washers between bolts and isolators. Bolt holes shall not be within the springs.

3. All mountings shall have leveling bolts.
4. Manufacturers:
    a. Mason "SLFH"
    b. Kinetics "FDS"
    c. Amber/Booth "SW-3, 4", 5" or 6"
    d. Vibration Eliminator Co. "OST"

2.3 HANGERS

A. Type H1:

1. Vibration hangers shall consist of a double-deflection neoprene element with a projecting bushing or oversized opening to prevent steel-to-steel contact.
2. Static deflection shall be at least 0.15" at calculated load and 0.35" at maximum rated load.
3. Provide hangers with end connections as required for hanging ductwork or piping.
4. Manufacturers:
    a. Mason "HD"
    b. Kinetics "RH"
    c. Aeroflex "RHD"
    d. Vibration Eliminator Co. "IC/3C/3CTD"
    e. Vibro Acoustics "RH"

B. Type H2:

1. Vibration hangers shall contain a steel spring in a neoprene cup with a grommet to prevent short circuiting the hanger rod.
2. The cup shall have a steel washer to distribute load on the neoprene and prevent its extrusion.
3. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30° arc before contacting the grommet and short circuiting the spring.
4. Provide end connections for hanging ductwork or piping.
5. Manufacturers:
    a. Mason "30"
    b. Kinetics "SH"
    c. Amber/Booth "BSRA"
    d. Aeroflex "RSH"
    e. Vibration Eliminator Co. "SNC"
    f. Vibro Acoustics "SH/SHC"

C. Type H3:

1. Vibration hangers shall have a steel spring in a neoprene cup with a grommet to prevent short circuiting of the hanger rod.
2. The cup shall have a steel washer to distribute load on the neoprene and prevent its extrusion.
3. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30° arc before contacting the grommet and short circuiting the spring.
4. Provide end connections for hanging ductwork or piping.
5. Hangers shall be capable of holding the load at a fixed elevation during installation. They shall have a secondary adjustment to transfer the load to the spring and maintain the same position.
6. Deflection shall be indicated by a pointer and scale.
7. Manufacturer:
    a. Mason "30N"
    b. Kinetics "SFH"
    c. Amber/Booth "BSW"
    d. Vibration Eliminator Co. "SNRC"
    e. Vibro Acoustics "SHR"

2.4 BASES

A. Type B3:

1. Rectangular structural channel concrete forms for floating foundations.
2. Where applicable, bases shall be large enough to support suction elbows, discharge elbows, and suction diffusers.
3. Channel depth shall be at least 1/12 the longest dimension of the base but not less than 6". Depth need not exceed 12" if rigidity is acceptable to equipment manufacturer.
4. Forms shall include 1/2" rebars welded on 6" centers running both ways in a layer 1-1/2" above the bottom, and drilled steel members with sleeves welded below the holes to receive the equipment anchor bolts.
5. Contractor shall pour 3,300 PSI concrete inside entire base. Concrete to be same thickness as sides of base. Trowel concrete smooth on top of base.
6. Use height saving brackets, unless noted otherwise.
7. Manufacturers:
   a. Mason "K"
   b. Kinetics "CIB-H"
   c. Aeroflex "MPF"
   d. Amber Booth "CPF"
   e. Bulldog, Inc.
   f. Vibration Eliminator Co. "SN"

2.5 FLEXIBLE CONNECTORS (NOISE AND VIBRATION ELIMINATORS)

A. Type FC1:

1. Spherical flexible connectors with multiple plies of nylon tire cord fabric and either EPDM or molded and cured neoprene. Outdoor units shall be EPDM.
2. Steel aircraft cables or threaded steel rods shall be used to prevent excess elongation.
3. All straight through connections shall be made with twin-spheres properly pre-extended as recommended by the manufacturer.
4. Connectors up to 2" size may have threaded ends.
5. Connectors 2-1/2" and over shall have floating steel flanges recessed to lock raised face neoprene flanges.
6. All connectors shall be rated for a minimum working pressure of 150 psi at 200°F.
7. Manufacturer:
   a. Metraflex "Double Cable-Sphere"
   b. Minnesota Flex Corp.
   c. Mercer "200 Series"
   d. Twin City Hose "MS2".

B. Type FC2:

1. Stainless steel flexible connectors with corrugated stainless steel hose body and stainless steel braided casing.
2. Rated for minimum working pressures of 150 psi at 70°F and 100 psi at 800°F.
3. Sizes 2" and under shall have steel threaded connections.
4. Sizes 2-1/2" and over shall have 150 lb. steel flanges.
5. Suitable for 1/2" permanent misalignment.
6. Manufacturers:
   a. Mason or Mercer "BSS-GU"
   b. Metraflex "ML"
   c. Twin City Hose "TCHS"
   d. American "BOA B4-1"
   e. Flexible Metal Hose Company "FM-21"
   f. Wheatley

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION

A. Install all products per manufacturer's recommendations.

B. Provide vibration isolation as indicated on the drawings and as described herein.

C. Clean the surface below all mountings that are not bolted down and apply adhesive cement equal to Mason Type WG between mounting and floor. If movement occurs, bolt mountings down. Isolate bolts from baseplates with neoprene washers and bushings.

D. All static deflections listed in the drawings and specifications are the minimum acceptable actual deflection of the isolator under the weight of the installed equipment - not the maximum rated deflection of the isolator.

E. Support equipment to be mounted on structural steel frames with isolators under the frames or under brackets welded to the frames. Where frames are not needed, fasten isolators directly to the equipment.

F. Where a specific quantity of hangers is noted in these specifications, it shall mean hanger pairs for support points that require multiple hangers, such as pipes supported on a strut rack.

3.2 PIPE ISOLATION

A. The first three hangers from vibration-isolated equipment shall be type H1.

B. For base mounted pumps without resilient mountings, the first five hangers shall be Type H1.

C. Where piping is floor-supported, use M2 instead of H1 and M3 instead of H2.

D. Install flexible connectors in all piping connected to vibration producing equipment. This includes all fans, base-mounted pumps, compressors, etc. Absence of flexible connectors on piping diagrams does not imply that they are not required.

E. Use Type FC1 where pressures are lower than 150 psi, temperatures are below 220°F, and the fluid handled is compatible with neoprene and EPDM.

F. Use Type FC2 for all other services. FC2 shall be installed parallel with equipment shafts.

G. Provide sufficient piping flexibility for vibrating equipment, or furnish flexible connectors with appropriate temperature and pressure ratings.

H. Vibration isolators shall not cause any change in position of piping that will result in stresses in connections or misalignment of shafts or bearings. Equipment and piping shall be maintained in a rigid position during installation. Do not transfer load to the isolators until the installation is complete and under full operational load. Hanger H3 and Mounting M4 may be used instead of other products for this purpose.

I. Support piping to prevent extension of flexible connectors.

3.3 VIBRATION ISOLATION SCHEDULE

A. Inline Pumps:

1. Base Type: NA
2. Isolator Type: M3 or H2 or H3

3. Static Deflection: 1.5"
4. Flexible Connections: NA

B. Base-Mounted Pumps:

1. Base Type: B3
2. Isolator Type: M3
3. Static Deflection: 1.5"
4. Flexible Connections: FC-1

END OF SECTION 21 05 48

VIBRATION ISOLATION SUBMITTAL FORM

COLUMN 1	2	3	4	5	6	7	8	9	10	11	12
		PROPOSED ISOLATOR							CALCULATIONS		
ITEM SERVED	MIN DEFL ("mm)	TAG	MODEL	MAX LOAD (#kg)	DEFL @ MAX LOAD ("mm)	DEFL TO SOLID ("mm)	FREE HT ("mm)	Kx/Ky	LOAD (#kg)	DEFL ("mm)	DEFL RATIO

COLUMN NOTES: Note numbers correspond to the column numbers above.
1. Item served should match designation on the design drawings.
2. List the deflection scheduled or specified in the design documents.
3. List the designation for this isolator. This is most useful when one item has multiple different isolators to support its weight.
4. List the manufacturer's complete model designation for the isolator.
5. List the manufacturer's maximum rated load for the isolator.
6. List the isolator deflection at the maximum rated load in column 5.
7. For spring isolators list the deflection when the springs are solid. This is not normally the same entry as in column 6.
8. List the height of the isolator when unloaded. Shop drawings must show where this is measured.
9. List the rated horizontal to vertical stiffness ratio. This must be between 0.8 and 2.0.
10. List the calculated equipment load on each isolator. For items with unequal weight distribution, calculate each isolator separately.
11. List the calculated deflection under the calculated load. For springs this will be column 10*(column 6 / column 5).
12. List the answer from dividing column 7 by column 11. This must be at least 1.5. If not, select an isolator with more nominal deflection.

GENERAL NOTES:
1. When submitting hangers or supports for a weight range, fill in two rows - one for the maximum and one for the minimum weight.

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SECTION 21 05 50 - SEISMIC REQUIREMENTS FOR EQUIPMENT AND SUPPORTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Seismic Requirements.

1.2 QUALITY ASSURANCE

A. General:

1. The contractor shall retain a specialty consultant or equipment manufacturer to develop a seismic restraint and support system and perform seismic calculations in accordance with these specifications, state, and local codes.
2. Items used for seismic restraint of equipment and systems shall be specifically manufactured for seismic restraint.
3. These requirements are beyond those listed in Section 21 05 29 of these specifications. Where a conflict arises between the seismic requirements of this section and any other section, the Architect/Engineer shall be immediately notified for direction to proceed.

B. Manufacturer:

1. System Supports/Restraints: Company specializing in the manufacture of products specified in this Section.
2. Equipment: Each company providing equipment that must meet seismic requirements shall provide certification included in project submittals the equipment supplied for the project meets or exceeds the seismic requirements of the project.

C. Testing Agency: An independent testing agency, acceptable to Authorities Having Jurisdiction, with experience and capability to conduct the testing indicated.

D. Installer: Company specializing in performing the work of this Section.

1.3 SUBMITTALS

A. Submit under provisions of Section 21 05 00.

B. Shop Drawings:

1. Calculations, restraint selections, and installation details shall be designed and sealed by a Professional Engineer licensed in the state where the project is located experienced in seismic restraint design and installation.
2. Coordination Drawings: Plans and sections drawn to scale, coordinating seismic bracing of mechanical components with other systems and equipment in the vicinity, including other seismic restraints.
3. Manufacturer's Certifications: Professional Engineer licensed in the state where the project is located shall review and approve manufacturer's certifications of compliance.
4. System Supports/Restraints - Submit for each condition requiring seismic bracing:

    a. Calculations for each seismic brace and detail utilized on the project.
    b. Plan drawings showing locations and types of seismic braces on contractor fabrication/installation drawings.

c. Cross-reference between details and plan drawings to indicate exactly which brace is being installed at each location. Details provided are to clearly indicate attachments to structure, correctly representing the fastening requirements of bracing.
d. Clear indication of brace design forces and maximum potential component forces at attachment points to building structure for confirmation of acceptability by the Structural Engineer of Record.

5. Equipment - Submit for each piece of equipment supplied:

a. Certification that the equipment supplied for the project meets or exceeds the seismic requirements specified.
b. Specific details of seismic design features of equipment and maximum seismic loads imparted to the structural support.
c. Engineering calculations and details for equipment anchorage and support structure.

C. A seismic restraint designer shall be provided whether or not exceptions listed in the applicable building code are met. If seismic restraints are not provided for a system that requires seismic bracing, the seismic designer shall submit a signed and sealed letter to the Architect/Engineer and Authorities Having Jurisdiction stating the exceptions, along with code reference, utilized for each item. Seismic designer shall review system installation for general conformance to the exception requirements stated in the code and document, in writing, the system has been installed in accordance to the exception.

1.4 TESTING AND INSPECTION

A. Special Inspection and Testing shall be done in accordance with Chapter 17 of the International Building Code.

B. The Owner shall employ a Special Inspection Agency to perform the duties and responsibilities specified in Section 1704 and 1705.

C. Work performed on the premises of a fabricator approved by the building official need not be tested and inspected. The fabricator shall submit a certificate of compliance that the work has been performed in accordance with the approved plans and specifications to the building official and the Architect and Engineer of Record.

D. The Special Inspection Agency shall furnish inspection reports to the building official, the Owner, the Architect, the Engineer of Record, and the General Contractor. The reports shall be completed and furnished within 48 hours of inspected work. A final signed report stating whether the work requiring special inspection was, to the best of the Special Inspection Agency's knowledge, in conformance with the approved plans and specifications shall be submitted.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site. Accept material on site in factory containers and packing. Inspect for damage. Protect from damage and contamination by maintaining factory packaging until installation. Follow manufacturer's instructions for storage.

1.6 DESIGN REQUIREMENTS

A. This project is subject to the seismic bracing requirements of the International Building Code, 2012 edition.

B. The following criteria are applicable to this project:

1. Risk Category: III
2. Seismic Importance Factor: I_E = 1.0Seismic Design Category: C

3. Component Amplification Factors (ap) and Component Response Modification Factors (Rp) shall be taken from Table 13.5-1 in ASCE 7-10 for the individual equipment or system being restrained.
4. Component Importance Factors (Ip) shall be taken from Section 13.1.3 in ASCE 7-10 for the individual equipment or system being restrained.
5. The total height of the structure and the height of the system to be restrained within the structure shall be determined in coordination with architectural plans and the General Contractor.

C. Forces shall be calculated with the above requirements and Equation 13.3-1, -2, and -3 of ASCE 7-10, unless exempted by 13.1.4.

D. Equipment shall meet International Building Code and ASCE 7 seismic qualification requirements in concurrence with ICC ES AC156 Acceptance Criteria for Seismic Qualification by Shake-Table Testing of Nonstructural Components and Systems.

1.7 COORDINATION

A. Coordinate layout and installation of seismic bracing with building structural systems and architectural features, and with mechanical, fire-protection, electrical and other building features in the vicinity.

B. Coordinate concrete bases with building structural system.

1.8 WARRANTY

A. Provide one-year warranty on parts and labor for manufacturer defects and installation workmanship.

PART 2 - PRODUCTS

2.1 SUPPLIERS

A. Following is a partial list of manufacturer/supplier contact information for seismic restraints:

1. B-Line Systems, Inc. (800) 851-7415, www.b-line.com.
2. Unistrut Corporation http://www.unistrut.us/
3. Kinetics Noise Control (877) 457-2695, www.kineticsnoise.com.
4. Mason Industries, Inc. www.mason-ind.com.
5. Loos & Co., Inc. (800) 321-5667, www.loosnaples.com.
6. Tolco (909) 737-5599, www.tolco.com
7. ISAT 877.523.6060, www.isatsb.com
8. Vibro-Acoustics (416) 291-7371, https://virs.vibro-acoustics.com/

2.2 SEISMIC DESIGN CRITERIA

A. This section describes the requirements for seismic restraint of systems and equipment related to continued operation of the facility after a design seismic event.

B. Definitions

1. Stay in Place:

a. All systems and equipment shall be anchored and restrained such that the anchoring system is intended not to fail and equipment and/or system components will not fall.

2. Remain Operational:

   a. Requirements for "Stay in Place" listed above shall be met.
   b. The following systems and associated equipment are intended not to fail externally or internally and are intended to remain operational.

      1) Fire Protection
      2) Heating
      3) Exhaust

2.3 SEISMIC BRACING AND SUPPORT OF SYSTEMS AND COMPONENTS

A. General:

1. Seismic restraint designer shall coordinate all attachments with the Structural Engineer of Record; refer to submittal requirements.
2. The seismic restraint design shall be based on actual equipment data obtained from manufacturer's submittals or the manufacturer. The equipment manufacturer shall verify and provide written certification the attachment points on the equipment can accept the combination of seismic, weight, and other imposed loads.
3. Design analysis shall include calculated dead loads, static seismic loads, and capacity of materials utilized for the connection of the equipment or system to the structure.
4. Analysis shall detail anchoring methods, bolt diameter, embedment, and weld length.
5. All seismic restraint devices shall be designed to accept without failure the forces calculated per the applicable building code.
6. All seismic restraints and combination isolator/restraints shall have verification of their seismic capabilities witnessed by an independent testing agency.

B. Friction from gravity loads shall not be considered resistance to seismic forces.

C. Housekeeping Pads:

1. Reinforced housekeeping pads shall be provided to handle shear, tension, and compression forces with proper reinforcement, doweling, and attachments connecting the pad to the structural slab.

2.4 SEISMIC RESTRAINT AND CONSTRUCTION OF EQUIPMENT

A. Equipment supplied for the project shall be designed to meet the requirements of lateral forces calculated using the applicable code and method described above.

B. The following is a partial list of equipment that shall be restrained and that shall be constructed to meet seismic forces described in this section:

1. Fire Protection Equipment
2. Fire Pumps

2.5 MATERIALS

A. Use the following materials for restraints:

1. Indoor Dry Locations: Steel, zinc plated.
2. Outdoors and Damp Locations: Galvanized steel.
3. Corrosive Locations: Stainless steel.

2.6 ANCHORAGE AND STRUCTURAL ATTACHMENT COMPONENTS

A. Strength: Defined in reports by ICC Evaluation Service or another agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Strength in tension and shear of components used shall be at least two times the maximum seismic forces to which they will be subjected.

B. Concrete and Masonry Anchor Bolts and Studs: Steel-expansion wedge type. Comply with IBC, ACI and ICC ES requirements for cracked concrete anchors.

C. Concrete Inserts: Steel-channel type.

D. Through Bolts: Structural type, hex head, high strength. Comply with ASTM F3125, Grade A 325.

E. Welding Lugs: Comply with MSS SP-69, Type 57.

F. Beam Clamps for Steel Beams and Joists: Double sided. Single-sided type is not acceptable.

G. Bushings for Floor-Mounted Equipment Anchors: Neoprene units designed for seismically rated rigid equipment mountings, and matched to the type and size of anchor bolts and studs used.

H. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for seismically rated rigid equipment mountings, and matched to the type and size of attachment devices used.

2.7 SEISMIC BRACING COMPONENTS

A. Slotted Steel Channel: 1-5/8-by-1-5/8-inch cross section, formed from 0.1046-inch-thick steel, with 9/16-by-7/8-inch slots at a maximum of 2 inches o.c. in webs, and flange edges turned toward web.

1. Materials for Channel: ASTM A 1011, GR 33.
2. Materials for Fittings and Accessories: ASTM A 635, ASTM A 576, or ASTM A 36.
3. Fittings and Accessories: Products of the same manufacturer as channels and designed for use with that product.
4. Finish: Baked, rust-inhibiting, acrylic-enamel paint applied after cleaning and phosphate treatment, unless otherwise indicated.

B. Channel-Type Bracing Assemblies: Slotted steel channel, with adjustable hinged steel brackets and bolts.

C. Cable-Type Bracing Assemblies: Zinc-coated, high-strength steel wire rope cable attached to steel thimbles, brackets, and bolts designed for cable service.

1. Arrange units for attachment to the braced component at one end and to the structure at the other end.
2. Wire Rope Cable: Comply with ASTM A 603. Use 49- or 133-strand cable with a minimum strength of 2 times the calculated maximum seismic force to be resisted.

D. Hanger Rod Stiffeners: Slotted steel channels with internally bolted connections to hanger rod.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer to the applicable code sections and Authority Having Jurisdiction for the exact seismic restraint requirements of piping, ductwork, conduit, equipment, etc.

B. Layout of transverse and longitudinal bracing shall follow recommendations of approved design standards listed in Part 1 of this specification section.

C. All rigid floor mounted equipment shall have a resilient media between the equipment mounting hole and the anchor bolt in concrete.

D. All seismic restraint systems shall be installed in strict accordance with the manufacturer's written instructions and all certified submittal data.

E. Installation of seismic restraints shall not cause any change in position of equipment, piping, or ductwork, resulting in stresses or misalignment.

F. No rigid connections between equipment and the building structure shall be made that degrade the noise and vibration-isolation system specified.

G. Do not install any equipment, piping, duct, or conduit that makes rigid connections with the building unless isolation is not specified.

H. Coordinate work with all other trades to avoid rigid contact with the building. Any conflicts with other trades that will result in rigid contact with equipment or piping due to inadequate space or other unforeseen conditions shall be brought to the Architect/Engineer's attention prior to specific equipment selection.

I. Prior to installation, bring to the Architect/Engineer's attention any discrepancies between the specifications and the field conditions, or changes required due to specific equipment selection.

J. Bracing may occur from flanges of structural beams, upper truss cords of bar joists, cast in place inserts, or International Code Council approved seismic anchors for installation in concrete.

K. Cable restraints shall be installed slightly slack to avoid short-circuiting the isolated suspended equipment, ductwork, piping, or conduit.

L. Cable assemblies shall be installed taut on non-isolated systems. Solid braces may be used in place of cables on rigidly attached systems only.

M. Do not install cables over sharp corners.

N. Brace support rods when necessary to accept compressive loads. Welding of compression braces to the vertical support rods is not acceptable.

O. Provide reinforced clevis bolts when required.

P. The vibration isolation manufacturer shall furnish integral structural steel bases as required. Independent steel rails are not acceptable.

Q. Post-Installed anchors shall be provided to meet seismic requirements.

R. Vertical pipe risers flexibly supported to accommodate thermal motion and/or pipe vibration shall be guided to maintain pipe stability and provide horizontal seismic restraint.

S. Seismic restraints shall be mechanically attached to the system. Looping restraints around the system is not acceptable.

T. Piping crossing building seismic or expansion joints, passing from building to building, or supported from different portions of the building shall be installed to allow differential support displacements without damaging the pipe, equipment connections, or support connections. Pipe offsets, loops, anchors, and guides shall be installed as required to provide required motion capability and limit motion of adjacent piping.

U. Water tanks shall be secured to their saddles by welding or proper concrete attachment, and those saddles shall be properly attached to the structure.

V. Brace all terminal units with water coils as required by the building code and provide flexible connection to the coil if bracing is required.

W. Independently brace duct mounted equipment (terminal units, in-line fans, etc.) and the associated suspended ductwork.

X. Do not brace a system to two different structures such as a wall and a ceiling.

Y. Provide appropriately sized openings in walls, floors, and ceilings for anticipated seismic movement. Provide fire seal systems in fire-rated walls.

Z. Positively attach all roof mounted equipment to roof curbs. Positively attach all roof curbs to building structure.

AA. Exposed seismic supports in occupied areas shall be guarded or covered to protect occupants.

BB. Coordinate seismic bracing of architecturally exposed ductwork with the Architect/Engineer.

3.2 SEISMIC RESTRAINT EXCLUSIONS

A. Refer to the applicable code sections and Authority Having Jurisdiction for allowable exclusions.

END OF SECTION 21 05 50

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SECTION 21 05 53 - FIRE SUPPRESSION IDENTIFICATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Identification of products installed under Division 21.

1.2 SUBMITTALS

A. Submit shop drawings under provisions of Section 21 05 00. Include list of items identified, wording, letter sizes, and color coding.

B. Include valve chart and schedule listing valve tag number, location, function, and valve manufacturer's name and model number.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. 3M

B. Bunting

C. Calpico

D. Craftmark

E. Emedco

F. Kolbi Industries

G. Seton

H. W.H. Brady

I. Marking Services.

2.2 MATERIALS

A. All pipe markers (purchased or stenciled) shall conform to ANSI A13.1. Marker lengths and letter sizes shall be at least the following:

OD of Pipe or Insulation	Marker Length	Size of Letters
Up to and including 1-1/4"	8"	1/2"
1-1/2" to 2"	8"	3/4"
2-1/2" to 6"	12"	1-1/4"
8" to 10"	24"	2-1/2"
Over 10"	32"	3-1/2"

Plastic tags may be used for outside diameters under 3/4"

B. Plastic Nameplates: Laminated three-layer phenolic with engraved black, 1/4” minimum letters on light contrasting background.

C. Brass Tags: Brass background with engraved black letters. Tag size minimum 1-1/2” square or 1-1/2" round.

D. Plastic Pipe Markers: Semi-rigid plastic, preformed to fit around pipe or pipe covering; indicating flow direction and fluid conveyed.

E. Vinyl Pipe Markers: Colored vinyl with permanent pressure sensitive adhesive backing.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all products per manufacturer's recommendations.

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

C. Valves:

1. All valves (except shutoff valves at equipment) shall have numbered tags.
2. Provide or replace numbered tags on all existing valves that are connected to new systems or that have been revised.
3. Provide all existing valves used to extend utilities to this project with numbered tags. Review tag numbering sequence with the Owner prior to ordering tags.
4. Secure tags with heavy duty key chain and brass "S" link or with mechanically fastened plastic straps.
5. Attach to handwheel or around valve stem. On lever operated valves, drill the lever to attach tags.
6. Number all tags and show the service of the pipe.
7. Provide one 36" x 24" (minimum) Plexiglas framed piping schematic showing valve locations with respective tag numbers. Mount directory in location chosen by the Architect/Engineer.

D. Pipe Markers:

1. Adhesive Backed Markers: Use Brady Style 1, 2, or 3 on pipes 3” diameter and larger. Use Brady Style 4, 6, or 8 on pipes under 3” diameter. Similar styles by other listed manufacturers are acceptable. Secure all markers at both ends with a wrap of pressure sensitive tape completely around the pipe.
2. Snap-on Markers: Use Seton "Setmark" on pipes up to 5-7/8” OD. Use Seton "Setmark" with nylon or Velcro ties for pipes 6” OD and over. Similar styles by other listed manufacturers are acceptable.
3. Stencil Painted Pipe Markers:

   a. Remove rust, grease, dirt, and all foreign substances from the pipe surface.
   b. Apply primer on non-insulated pipes before painting.
   c. Use background and letter colors as scheduled later in this section.

4. Apply markers and arrows in the following locations where clearly visible:

   a. At each valve.
   b. On both sides of walls that pipes penetrate.
   c. At least every 20 feet along all pipes.
   d. On each riser and each leg of each "T" joint.
   e. At least once in every room and each story traversed.

E. Equipment:

1. All equipment not easily identifiable such as controls, relays, gauges, etc.; and all equipment in an area remote from its function shall have nameplates or plastic tags listing name, function, and drawing symbol. Do not label exposed equipment in public areas.
2. Fasten nameplates or plastic tags with stainless steel self-tapping screws or permanently bonding cement.
3. Mechanical equipment that is not covered by the U.S. National Appliance Energy Conservation Act (NAECA) of 1987 shall carry a permanent label installed by the manufacturer stating that the equipment complies with the requirements of ASHRAE 90.1.

3.2 SCHEDULE

A. Pipes to be marked shall be labeled with text shown as follows, regardless of which method or material is used:

1. FIRE PROTECTION WATER: White lettering; red background
2. SPRINKLER WATER: White lettering; red background

B. All piping downstream of the fire protection backflow preventer, upstream of sprinkler zone valves, standpipe piping, and combination sprinkler standpipe piping shall be labeled Fire Protection Water. All piping downstream of sprinkler zone valves shall be labeled Sprinkler Water.

END OF SECTION 21 05 53

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SECTION 21 13 02 - FIRE PROTECTION SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Pipe, Fittings, Valves, and Connections for Fire Protection System.

B. Wet-Pipe Sprinkler System.

C. Standpipe System.

1.2 QUALITY ASSURANCE

A. Welding Materials and Procedures: Conform to ASME Code.

B. Equipment and Components: Bear UL label or marking.

C. Valves: Bear UL label or marking. Provide manufacturer's name and pressure rating marked on valve body. Pressure rating shall match specified pipe system pressure rating. Remanufactured valves are not acceptable.

D. Specialist Firm: Company specializing in sprinkler systems with minimum three years' experience.

E. Sprinkler design drawings submitted by the Contractor shall be prepared by a NICET Water-Based Fire Protection Systems Layout Level III or Level IV designer or PE.

1.3 SUBMITTALS

A. Submit shop drawings per Section 21 05 00. Indicate pipe materials, joining methods, supports, floor and wall penetration seals, sprinklers, equipment data and ratings, and hydraulic calculations.

B. Submit detailed pipe and sprinkler layout and other calculations and forms as described in NFPA 13.

C. Submit detailed working drawings and obtain review of them in the following order:

1. Engineer/Architect State Fire Marshal/Authority Having Jurisdiction
2. Owner's Insurance Company
3. Architect/Engineer
4. Department of Health and Family Services (Hospitals, Nursing Homes, CBRF's only)
5. Local Fire Department
6. Owner's Insurance Company
7. Architect/Engineer

D. Working drawings shall include piping and sprinkler layout, sprinkler types and ratings, sections and elevations at critical points. Show coordination with lighting, ductwork, and diffusers, and indicate basic flow and hydraulic design information, including main location and date that the test was taken.

E. Submit dry-pipe calculations including water delivery time and air supply refill defined in NFPA 13. Water delivery time and air supply shall meet the requirements set forth in NFPA 13.

F. Submit electrical power/controls wiring diagrams and product data indicating general assembly, components, safety controls, and service connections.

G. Provide the Owner with one copy of NFPA 25. Standard for the Inspection Testing and Maintenance of Water-based Fire Protection Systems.

1.4 EXTRA STOCK

A. Provide metal storage cabinet, wrenches for each sprinkler type, and extra sprinklers per NFPA 13 and applicable building code.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store valves and sprinklers in shipping containers, with labels in place.

B. Provide temporary protective coating on iron and steel valves.

C. Maintain temporary end caps and closures in place until installation.

1.6 WORK FURNISHED BUT INSTALLED UNDER OTHER SECTIONS

A. Furnish sleeves to General Contractor for placement in walls and floors. Sleeve location to be determined by the Fire Protection Contractor prior to construction. If additional sleeves are required, they shall be core drilled by the Fire Protection Contractor.

1.7 SYSTEM DESCRIPTION

A. Contractor shall design and install the following water-based fire protection systems for the areas noted on the contract documents:

1. Wet pipe sprinkler system(s)
2. Dry pipe sprinkler system(s)
3. Standpipe system(s)

B. Sprinkler systems shall be designed and installed according to the following standard(s):

1. NFPA 13 - Standard for the Installation of Sprinkler Systems

C. Standpipe system shall be designed and installed according to the following standard(s):

1. NFPA 14 - Standard for the Installation of Standpipe and Hose Systems

D. System design and installation shall include all requirements by the Authority Having Jurisdiction, local and state building codes, and Owner's insurance company in addition to the previously listed design standard(s). Those requirements shall take precedence over the contract documents in the case of discrepancies.

E. Systems shall be hydraulically calculated in accordance with the applicable design standard(s). Contractor is responsible for final pipe sizing based on results from hydraulic calculations. Pipe sizing shown on drawings for service entrance and main risers is preliminary and for coordination purposes only.

F. The water supply source for this project is the following:

1. Public waterworks system with fire pump.
2. Refer to Section 21 30 00 for fire pump performance requirements.

3. The system design shall be based on water supply information provided on the contract drawings. Supply shall be presumed to be at the point of connection to existing water supply infrastructure unless noted otherwise. The Fire Protection Contractor is responsible to verify this information and conduct all tests required. Base all pipe sizing and hydraulic calculations on flow test data no older than 12 months.
4. System design shall be based on the following water supply information. Supply shall be presumed to be at the point of connection to existing water supply infrastructure unless noted otherwise. The Fire Protection Contractor is responsible to verify this information and conduct all tests required. Base all pipe sizing and hydraulic calculations on flow test data no older than 12 months.

    a. Date of Test: May 10, 2021
    b. Test Conducted By:MSU Facilities
    c. Static Pressure: 50 psig
    d. Residual Pressure: 25 psig
    e. Flow at Residual Pressure: 950 GPM

5. System design shall provide a safety factor when comparing available water supply pressure versus system design pressure at design flow rate (including hose streams). The safety factor shall be the following:

    a. 5 psig

G. Coordinate with Plumbing Contractor for installation of a floor drain with collection funnel below the backflow preventer.

1.8 COORDINATION DRAWINGS

A. Reference Coordination Drawings article in Section 21 05 00 for required fire protection systems electronic CAD drawings to be provided to Coordinating Contractor for inclusion into composite coordination drawings.

1.9 OPERATION AND MAINTENANCE DATA

A. Submit manufacturers' operation and maintenance data. Include written maintenance data on components of system, servicing requirements, and record drawings.

1.10 JOB CONDITIONS

A. Fire Protection Contractor shall determine the flow and pressure available at the service connection. The Fire Protection Contractor is responsible to verify this information and make all tests required. Base all pipe sizing and hydraulic calculations on flow test data no older than 18 months.

PART 2 - PRODUCTS

2.1 PIPE AND FITTINGS - WET PIPE SPRINKLER SYSTEMS

A. Piping - 2” and Under (Steel Pipe):

1. Design Pressure: 175 psig
2. Pipe: Schedule 40, black steel, ASTM A53, ASTM A795, UL/FM. Inner wall shall be coated with an anti-MIC (microbiologically influenced corrosion) coating.

3. Fittings:

   a. Threaded:

      1) Cast iron, Class 125, black, UL, ANSI/ASME B16.4.
      2) Malleable iron, Class 150, black, UL, ANSI/ASME B16.3.
      3) Ductile iron, Class 150, black, UL, ANSI/ASME B16.3.

   b. Grooved:

      1) Ductile iron housing ASTM A-536, Grade 65-45-12, UL, enamel coating, Grade E (Type A) EPDM molded pressure-responsive gaskets suited for 40°F to 150°F. Carbon steel bolts and nuts.

   c. Flanged:

      1) Cast iron, Class 125, black, UL, ANSI/ASME B16.1.

4. Unions: Class 150 malleable iron, ANSI B16.39, ground joint with copper or copper alloy-to-iron seat.

B. Piping - 2-1/2" and Above (Steel Pipe):

1. Design Pressure: 175 psig
2. Pipe: Schedule 40, black steel ASTM A53, ASTM A795, UL. Inner wall shall be coated with an anti-MIC (microbiologically influenced corrosion) coating.
3. Joints: Grooved or flanged.
4. Fittings:

   a. Grooved:

      1) Ductile iron housing ASTM A-536, Grade 65-45-12, UL, enamel coating, Grade E (Type A) EPDM molded pressure-responsive gaskets suited for 40°F to 150°F. Carbon steel bolts and nuts.

   b. Flanged:

      1) Cast iron, Class 125, black, UL, ANSI/ASME B16.1.

2.2 FLEXIBLE FIRE SPRINKLER CONNECTIONS

A. Flexible Connection: Stainless steel hose, 175 psig max working pressure, fully welded non-mechanical fittings, stainless steel braid, maximum of 6' hose length, leak-tested with a minimum 7/8" internal corrugated hose diameter made of 304 stainless steel, end fittings made of carbon or stainless steel. Outlet of end fittings shall be 1/2" or 3/4" to match sprinkler connection. UL.

B. Ceiling Bracket: G90 galvanized steel, direct attachment type, integrated snap-on clip ends, tamper resistance screws, removable attachment hub with set screw for attachment and adjustment of stainless steel hose.

1. Manufacturers:

   a. Flexhead Industries
   b. Victaulic VicFlex,
   c. Sprinkflex
   d. or approved equal.

2.3 PIPE AND FITTINGS - DRY PIPE SPRINKLER SYSTEMS

A. Piping - 2" and Under (Steel):
   1. Design Pressure: 175 psig Pipe: Schedule 40, black steel, ANSI/ASTM A153, ASTM A795, UL. Inner wall shall be coated with an anti-MIC (microbiologically influenced corrosion) coating.
   2. Joints: Threaded or roll grooved or flanged.
   3. Fittings:
      a. Threaded:
         1) Cast iron, Class 125, black, UL, ANSI/ASME B16.4.
         2) Malleable iron, Class 150 black, UL, ANSI/ASME B16.3.
         3) Ductile iron, Class 150, black, UL, ANSI/ASME B16.3.
      b. Grooved:
         1) Ductile iron housing ASTM A-536, Grade 65-45-12, UL, enamel coating, Grade E (Type A) EPDM molded pressure-responsive gaskets suited for 40°F to 150°F. Carbon steel bolts and nuts. Provide flush gap style gasket. Lubricate gasket according to manufacturer recommendations.
      c. Flanged:
         1) Cast iron, Class 125, black, UL, ANSI/ASME B16.1.
   4. Unions: Class 150 malleable iron, ANSI B16.39, ground joint with copper or copper alloy-to-iron seat.

B. Piping - 2-1/2" and Above:
   1. Design Pressure: 175 psig
   2. Pipe: Schedule 40, black steel, ANSI/ASTM A53, ASTM A795, UL. Inner wall shall be coated with an anti-MIC (microbiologically influenced corrosion) coating.
   3. Joints: Roll grooved or cut grooved or flanged.
   4. Fittings:
      a. Grooved:
         1) Ductile iron housing ASTM A-536 Grade 65-45-12, UL, enamel coating, Grade E (Type A) EPDM molded pressure-responsive gaskets suited for 40°F to 150°F. Carbon steel bolts and nuts.
      b. Flanged:
         1) Cast iron, Class 125, black, UL/FM, ANSI/ASME B16.1.

2.4 PIPE AND FITTINGS - WET STANDPIPE SYSTEM

A. Refer to Article 2.1 PIPE AND FITTINGS - WET PIPE SYSTEMS.

2.5 PIPE AND FITTINGS - DRY STANDPIPE SYSTEM

A. Refer to Article 2.2 PIPE AND FITTINGS - DRY PIPE SYSTEMS.

2.6 VALVES

A. Provide handwheels for gate valves. Provide gear operators for butterfly valves.

B. Provide all connections to match pipe joints. Valves shall be same size as pipe.

2.7 BACKFLOW PREVENTERS

A. Provide backflow preventers as required by code and as specified on the drawings.

2.8 EQUIPMENT

A. Equipment shall be as scheduled on the drawings.

2.9 RISER LABELING AND IDENTIFICATION

A. Hydraulic nameplates shall be affixed to each riser and shall include the following minimum information:

1. Installation contractor
2. Date installed
3. Riser location
4. Number of sprinklers
5. Basis of design (density GPM/ft2 and area of coverage ft2
6. Water flow rate (GPM) and residual pressure (psi) at the base of riser
7. Hose stream allowance (GPM).
8. Occupancy classification
9. Commodity classification (If applicable)
10. Maximum storage height (if applicable)

B. A dedicated antifreeze placard is required where a remote antifreeze system is provided. The placard is to be placed on the main valve serving the antifreeze system to document the manufacturer type and brand of the solution and the system volume.

2.10 PIPE LABELING AND IDENTIFICATION

A. All pipe shall be marked along its length by the manufacturer in such a way as to properly identify the type of pipe. The manufacturer pipe marking shall be visible on every piece of pipe over 2 ft (600 mm) long. Manufacturer pipe identification shall include the manufacturer's name, model designation, and/or schedule. Provide additional identification as described in Section 21 05 53.

PART 3 - EXECUTION

3.1 INSTALLATION - PIPING

A. General Installation Requirements:

1. Coordinate piping and sprinkler locations with all other trades. Ductwork, diffusers and light fixture locations shall have priority over sprinkler piping and sprinklers.
2. Ream pipe and tube ends to full inside diameter. Remove burrs. Remove scale and foreign material, inside and outside, before assembly.
3. Die cut screw joints with full cut standard taper pipe threads.
4. Coat threads with pipe joint compound or wrap with Teflon tape.
5. Locate piping to minimize obstruction of other work.

6. Route piping in concealed spaces above finished ceiling.
7. Use full and double lengths of pipe wherever possible.
8. Slope all piping for complete drainage. Install auxiliary drains for all trapped piping per NFPA 13.
9. Reducers are generally not shown. Where pipe sizes change at tee, the tee shall be the size of the largest pipe shown connecting to it.
10. Comply with manufacturer's installation instructions.

B. Steel Piping:

1. In steel piping, main sized saddle branch connections or direct connection of branches to main is permitted if main is one pipe size larger than the branch for up to 6" mains and if main is two pipe sizes larger than branch for 8" and larger mains. Do not project branch pipes into main pipes.

C. Wall/Floor Penetration:

1. Provide sleeves when penetrating floors and walls.
2. Seal pipes passing through exterior walls with a wall seal per Section 21 05 29. Provide Schedule 40 galvanized sleeve at least 2 pipe sizes larger than the pipe. Sleeves through floors shall extend minimum 1.5" above finished floor.
3. Fire seal all pipe and sleeve penetrations (both wall and floor) to maintain fire separation required without restraining pipe.

D. Installation Requirements in Electrical Rooms:

1. Do not install piping or other equipment above electrical switchboards or panelboards. This includes a dedicated space extending 25 feet from the floor to the structural ceiling with width and depth equal to the equipment. Fire protection equipment dedicated to the electrical equipment room or space may be installed above equipment if other alternatives are not available.

E. Hangers and Supports:

1. Provide hangers and supports as required by NFPA 13 and UL, with the following exceptions:

   a. Do not use powder driven devices, explosive devices, wooden plugs, or plastic inserts.
   b. Do not install fasteners to carry the load in tension, unless absolutely necessary.

F. Exposed Piping:

1. Install chrome plated steel escutcheons where exposed pipes penetrate walls or floors.
2. Remove all scale, rust, dirt, oils, stickers and thoroughly clean exterior of all bare metal exposed piping, hangers, and accessories in preparation to be painted.

3.2 INSTALLATION - VALVES

A. Install gate valves with stems upright or horizontal, not inverted.

B. Backflow Preventer:

1. Provide an air gap fitting and piping to drain. On 2-1/2" and larger units, install a tail piece from air gap fitting to drain to prevent water from spraying out of drain air gap receptor. Maintain air gap distance required by Code.
2. Units shall be field tested and tagged in accordance with manufacturer's instructions by a certified tester before initial operation.
3. Install unit between 12" and 60" above finish floor.
4. Provide monitor switches on all shutoff valves.

C. Shutoff Valve:

1. Install buried shutoff valves in valve boxes. Provide post indicators.
2. Provide drain valves at main shutoff valves, low points of piping and apparatus.
3. Provide monitor switches on all shutoff valves.

3.3 INSTALLATION - EQUIPMENT

A. Coordinate piping and sprinkler locations with all other trades. Ductwork, diffusers and light fixture locations shall have priority over system equipment and sprinklers.

B. Fire Department Connection:

1. Locate fire department connection in an accessible location as approved by the local fire department with sufficient clearance from walls, obstructions, and adjacent Siamese connectors to allow full swing of fire department wrench handle.

C. Alarm Bell:

1. Locate outside alarm bell on building wall as shown on drawings.
2. Wire all bells, flow switches and supervisory switches to fire alarm system. All wiring shall be in conduit and meet the requirements of the electrical specifications.

D. Test Valves:

1. Install test valves where required. Pipe to outdoors or drain. Test connection shall have flow equivalent to the smallest K-factor sprinkler.

E. Sprinklers:

1. Locate sprinklers to clear lights, ducts and diffusers. Do not run sprinkler pipes through ducts. Ductwork has priority over sprinkler pipes. Offset pipes as needed.
2. Center sprinklers in two directions in ceiling tiles and provide offsets as required.
3. Do not allow concealed sprinkler cover plates to be painted. Sprinkler cover plates are to be factory painted only. Do not field paint.
4. Apply strippable or paper covers so concealed sprinkler cover plates do not receive field paint finish.

F. Double Interlocked Preaction System:

1. Provide all valves, switches, detectors and all wiring to devices from the alarm control panel.

3.4 INSTALLATION - STANDPIPE AND HOSE SYSTEM

A. Locate and secure hose cabinet plumb.

B. Locate angle valve in cabinet at 60" above floor. Locate fire department connection below angle valve and not closer than 4" from side or bottom of cabinet.

C. Connect wet standpipe system to water source ahead of domestic water connection.

D. Where static pressure exceeds 175 psig at any hose station, provide pressure regulating valves to limit the pressure on hose to 100.

E. Where residual pressure at Class III hose station1-1/2" exceeds 100 psig, provide a pressure regulating valve to limit the residual pressure on the hose to 100 psig.

F. Provide connection for alarm and supervisory control to building alarm system.

G. Install backflow preventer as required by local Authorities Having Jurisdiction and as indicated on Fire Protection Material List.

3.5 SYSTEMS CLEANING AND TESTING

A. General Requirement:

1. All water used for testing and remaining in the piping system shall be obtained from a potable water source.

B. Underground Piping:

1. Flush all underground piping with minimum flow equal to the system design flow but not less than the following:

a. 390 gpm for 4" pipes.
b. 880 gpm for 6" pipes.
c. 1560 gpm for 8" pipes.
d. 2440 gpm for 10" pipes.
e. 3500 gpm for 12" pipes.

2. Branches from existing or new underground mains to sprinkler risers shall be flushed out through two 2-1/2" hoses (with flow through open hose butts) attached to the riser with 4" temporary piping. Flushing through the drain of an alarm check or dry pipe valve is not acceptable.

C. Interior Piping:

1. Verify adequate water flow at the inspector's test connection.
2. Flush all interior piping to remove scale and other foreign material before placing system into service.
3. Hydrostatically test the entire interior piping system at a minimum of 200 psig or 50 psig more than the normal system working pressure for systems subjected to pressures more than 150 psig. Maintain test pressure for 2 hours without loss of pressure. Test shall be performed with dry pipe valves in open position to prevent valve damage.

D. Standpipe and Hose Systems:

1. Hydrostatically test standpipe and hose systems in accordance with NFPA 14 and applicable building code requirements.

E. Dry Piping:

1. On dry-pipe systems, also test the interior piping with an air pressure of 40 psi for 24 hours. Pressure loss shall not exceed 1-1/2 psi in 24 hours with allowance made for temperature change. An odorant, such as oil of wintergreen, may be added to help locate leaks.

F. Fire Alarm System:

1. Test the alarm system by operating the inspector's test connection or the alarm test valves. Verify that the building fire alarm system activates.
2. Adjust all monitor switches for proper operation.

END OF SECTION 21 13 00

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SECTION 21 30 00 - FIRE PUMPS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Fire Pump Package.

B. Fire Pump Motor.

C. Electric Pressure Maintenance (Jockey) Pump.

D. Controllers.

1.2 QUALITY ASSURANCE

A. Provide pumps with manufacturer's name, model number, and rating/ capacity.

B. Test pump, driver, and controller in accordance with NFPA 20. Test shall be witnessed by authority having jurisdiction.

C. Manufacturer: Company specializing in manufacture of the products in this section with minimum three years documented experience.

D. Installer: Company specializing in performing the work of this section with minimum three years documented experience.

E. Equipment and components bear UL label or marking.

F. Source Limitations: Obtain fire pumps, pressure maintenance pumps, and controllers through one source.

1.3 SUBMITTALS

A. Submit shop drawings per Section 21 05 00 and Section 21 13 00.

B. Product Data: For each type of product indicated, include pump type, rated capacities, power requirements (including in-rush current draw upon pump start-up), certified pump performance curves with each selection point indicated, NPSH curve, operating characteristics, and furnished accessories and specialties for each fire pump and pressure maintenance pump.

C. Shop Drawings: For fire pumps and drivers, fire pump controllers, fire pump accessories and specialties, pressure maintenance pumps, pressure maintenance pump controllers, and pressure maintenance pump accessories and specialties, include plans, elevations, sections, details, and attachments to other work.

D. Submit Manufacturer's Installation Instructions: Include start-up instructions for fire pump system.

E. Submit Manufacturer's Certification that fire pumps meet or exceed specified requirements at specified operating conditions. Submit summary and results of shop tests performed in accordance with NFPA 20.

F. Submit summary of hydrostatic test and field acceptance tests performed in accordance with NFPA 20.

G. Submit electrical power/controls wiring diagrams and product data indicating general assembly, components, safety controls, and service connections.

1.4 EXTRA MATERIALS

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

1.5 DELIVERY, STORAGE, AND HANDLING

A. Accept fire pumps and components at site in factory packing. Inspect for damage. Comply with manufacturers rigging and installation instructions.

B. Protect fire pumps and components from damage, including weather, water and construction debris.

C. Provide temporary inlet and outlet caps, and maintain in place until installation.

1.6 SYSTEM DESCRIPTION

A. Electric motor driven horizontal fire pump with jockey pump and electric controllers.

1.7 REGULATORY REQUIREMENTS

A. All materials and installation shall conform to NFPA 20.

B. Provide certificate of compliance from authority having jurisdiction indicating approval of field acceptance tests. Coordinate date and time of acceptance testing with Facilities Maintenance. Facilities Maintenance shall hav ethe option of having members of their team present during acceptance testing. Provide acceptance certificates to Facilities Maintenance.

C. All material, equipment and installation shall be approved by the State Fire Marshal and the Owner's insurance company.

D. The Owner's insurance company and State Fire Marshal shall have precedence over the drawings and specifications in case of discrepancies.

1.8 OPERATION AND MAINTENANCE DATA

A. Include manufacturer's instructions, start-up data, and trouble-shooting check lists for pumps, drivers and controllers, cleaning procedures, replacement parts lists, and repair data for pumps, drivers and controllers.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Fire Pumps:

1. Aurora Pumps - Basis of Design
2. Fairbanks Morse
3. Peerless Pump
4. A-C Pump; ITT Industries
5. Patterson Pump

B. Controllers:

1. Tornatech
2. Firetrol (ASCO)
3. Master Control Systems
4. Cutler-Hammer (Eaton)
5. Metron (Hubbell)

2.2 HORIZONTAL BASE MOUNTED PUMPS

A. Type: UL 448 and UL 778, horizontal shaft, single stage, double suction, direct connected, horizontally split casing, for 250 psi maximum working pressure. Fire pump shall be capable of furnishing not less than 150 percent of rated capacity at not less than 65 percent of total rated head and with shutoff head limited to 140 percent of total rated head. Factory assembled and tested to comply with NFPA 20.

B. Casing: Cast iron, with suction and discharge gauge ports, renewable bronze casing wear rings, seal flush connection, drain plug, flanged suction and discharge.

C. Impeller: Bronze, double suction, fully enclosed, balanced and keyed to shaft.

D. Bearings: Grease lubricated ball bearings in cast iron housing.

E. Shaft and Sleeve: Alloy steel with replaceable bronze shaft sleeve.

F. Seal: Packing gland with minimum four rings graphite impregnated packing and lantern rings, 230°F maximum continuous operating temperature.

G. Drive: Flexible coupling with coupling guard.

H. Baseplate: Cast iron or fabricated steel with integral drain rim.

I. Finish: Manufacturer's standard red paint.

J. Provide nameplate complete with rated capacities and pump characteristics.

K. Performance: Refer to Schedule on drawings.

2.3 FIRE PUMP ACCESSORIES

A. OS&Y gate valve on pump suction. All valves associated with the fire protection system shall be electrically supervised by the fire alarm system.

B. If necessary to reduce pipe size at pump suction flange, provide eccentric reducer.

C. Concentric increaser and check valve in pump discharge and OS&Y gate or butterfly valve on system side of check valve.

D. Fire pump bypass with OS&Y gate or butterfly valves and check valve.

E. Spring loaded main relief valve, UL 1478, and enclosed type waste cone.

F. Suction pressure gauge with snubber, valve and lever handle.

G. Discharge pressure gauge mounted on board attached to pump, with snubber, valve and lever handle.

H. Casing 3/4" relief valve.

I. Float operated 1" automatic air release valve.

J. Fire pump test connection with 2-1/2" hose valves with caps and chains.

K. Flow metering system for closed loop testing.

1. Description: Fire pump flowmeter system that indicates flow to not less than 175 percent of fire pump rated capacity. Include sensor of size to match pipe, tubing, flowmeter, and fittings.
2. Pressure Rating: 175 psig minimum.
3. Sensor: Venturi, annubar probe, or orifice plate, unless otherwise indicated.
4. Flow Meter: Compatible with flow sensor with dial not less than 4-1/2 inches in diameter or manufacturer's equivalent size.
5. Permanently Mounted Flow Meter: Suitable for wall mounting with copper tubing to connect to flow sensor.

L. Splash shield between pump and motor.

M. Finish: Manufacturer's standard red paint.

2.4 ELECTRIC MOTOR DRIVE

A. Motor: UL listed, squirrel cage induction type in open drip-proof NEMA MG1 enclosure 3550 RPM complying with NFPA 20 and NFPA 70.

B. Controller: UL 218 and NFPA 20, full service type with solid state reduced voltage starter and electrical characteristics as scheduled on the drawings, in NEMA 3R enclosure, combined automatic and manual operation, factory assembled and wired, and factory tested for capacities and electrical characteristics, including the following:

1. Disconnect Means: Externally operable, quick-break type.
2. Circuit Breaker: Continuous current rating not less than 600% of the rated full load current of the motor. Overcurrent sensing elements of the non-thermal type. Instantaneous short circuit current rating for 100,000 amperes interrupting capacity and service entrance rated.
3. Locked Rotor Protection: Calibrated and set at a minimum of 600% of full load current.
4. Motor Starter: Energized automatically by pressure switch or manually by externally operable handle.
5. Pressure Switch: Water pressure actuated switch with independent high and low calibrated adjustments responsive to water pressure in fire suppression piping. This Contractor is responsible for determining and setting start and stop pressures based on hydraulic calculations, available water pressure, required system pressure, controller manufacturer's recommendations, and NFPA requirements.
6. Running Timer: Keeps motor operating when started automatically, for at least ten minutes.
7. Pilot Lamp: Indicates circuit breaker closed and power available.
8. Ammeter and voltmeter built into enclosure.
9. Built-in Alarm: Energizes alarm to indicate circuit breaker open or power failure.
10. Remote start switch relay.
11. Contacts for monitoring PHASE LOSS, PHASE REVERSAL, PUMP RUNNING, PUMP FAIL TO START, and ALTERNATE SOURCE.
12. Controller Sensing Pipes: Fabricate pipe and fittings according to NFPA 20 with nonferrous metal sensing piping, NPS 1/2, with globe valves for testing controller mechanism from system to pump controller as indicated. Include bronze check valve with 3/32 inch orifice in clapper or ground face union with non-corrosive diaphragm having 3/32 inch orifice.
13. Automatic Transfer Switch connected to primary and alternate power source: UL 218 and UL 1008 and requirements for and attached to fire pump controllers. Include enclosure complying with UL 50, Type 2, with automatic transfer switch with rating at least equal to fire pump driver motor horsepower. Include ampere rating not less than 115 percent of motor full load current and suitable for switching motor locked rotor current. Instantaneous short circuit current rating for 100,000 amperes interrupting capacity and service entrance rated.

14. Remote Start Circuit Monitoring: Provide continuous monitoring of the generator start circuits. A failure shall initiate visual and audible alarms at the generator, remote annunciators, and start the generator.
15. Surge Protection: Provide a factory-installed listed surge protection device with the fire pump controller.
16. System Pressure Recorder: Digital type with memory.
17. Finish: Manufacturer's standard red paint.

2.5 PRESSURE MAINTENANCE (JOCKEY) PUMP

A. Pressure Maintenance Pumps: Factory assembled and tested pumps with electric motor driver, controller, and accessories and specialties. Include cast iron or stainless steel casing and bronze or stainless steel impellers, mechanical seals, and suction and discharge flanges machined to ASME B16.1, Class 125 dimensions unless Class 250 flanges are indicated and except that connections may be threaded in sizes where flanges are not available.

B. Electrically operated, horizontal turbine type with NEMA MG1, open drip-proof squirrel cage induction motor complying with NFPA 20 and NFPA 70. Include wiring compatible with controller used.

C. Provide suction and discharge pressure gauges.

D. Provide with pressure relief valve and pipe to outdoors.

E. Control by automatic jockey pump controller to start pump on pressure drop in system. Fire pump starts automatically on further pressure drop or on jockey pump failure.

F. Controllers: UL 508, factory assembled, wired, and tested across the line type for combined automatic and manual operation.

1. Enclosure: UL 508 and NEMA 250, Type 2, wall mounting type for field electrical wiring.
2. Controller Sensing Pipes: Fabricate pipe and fittings according to NFPA 20 with nonferrous metal sensing piping, NPS 1/2, with globe valves for testing controller mechanism from system to pump controller as indicated. Include bronze check valve with 3/32 inch orifice in clapper or ground face union with non-corrosive diaphragm having 3/32 inch orifice.
3. Rate controller for scheduled horsepower, and include the following:

    a. Fusible disconnect switch.
    b. Pressure switch.
    c. Hand-off-auto selector switch.
    d. Pilot light.
    e. Running period timer.

4. Finish: Manufacturer's standard color paint applied to factory assembled and tested unit before shipping.

G. Performance: Refer to schedule on drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions, NFPA 20, and NFPA 37.

B. Provide at least the manufacturer's recommended minimum service space around pumps. The installing contractor shall provide a submittal drawing that shows the routing of all pipe, wiring, conduit, clearances and equipment in relation to the fire pump room. Routing shall be such that does not cause trip hazards or restrict access.

C. Coordinate work of this section with other affected work.

D. Decrease from line size with long radius reducing elbows or reducers. Support piping adjacent to pump so no weight is carried on pump casings. For base mounted pumps, provide supports under suction and discharge elbows. Refer to Section 21 13 00.

E. Provide drains for bases and seals, piped to and discharging into floor drains.

F. Install eccentric reducer at suction flange with flat side on top to avoid air pockets in suction piping.

G. Lubricate pumps before start-up.

H. Qualified millwright shall check, align, and certify base mounted pumps prior to start-up.

I. Mount unit on vibration isolators. Refer to Section 21 05 48.Insulate piping associated with pump, pump casing and exhaust silencer. Refer to Section 21 07 16 and Section 21 07 19.

J. Control and Signal Cabling: Provide control and signal cabling per manufacturer recommendations for the following system components.

1. Remote annunciator.
2. Emergency generator start signals. The generator start signal cabling shall be fire protected for a minimum of 2 hours using an approved method:

    a. Raceway or cable encased in a minimum of 2 inches of concrete cover.
    b. Listed fire resistive raceway / cable system.
    c. Raceway / cable is protected by a listed electrical circuit protective system.

END OF SECTION 21 30 00

SECTION 22 05 00 - BASIC PLUMBING REQUIREMENTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Requirements applicable to all Division 22 Sections. Also refer to Division 1 - General Requirements.

B. All materials and installation methods shall conform to the applicable standards, guidelines and codes referenced herein and within each specification section.

1.2 DIVISION OF WORK BETWEEN MECHANICAL, ELECTRICAL & CONTROL CONTRACTORS

A. Definitions:

1. "Mechanical Contractors" refers to the following:
    a. Plumbing Contractor.
    b. Heating Contractor.
    c. Air Conditioning and Ventilating Contractor.
    d. Temperature Control Contractor.
    e. Fire Protection Contractor.
    f. Testing, Adjusting, and Balancing Contractor.
2. Motor Control Wiring: The wiring associated with the remote operation of the magnetic coils of magnetic motor starters or relays, or the wiring that permits direct cycling of motors by means of devices in series with the motor power wiring. In the latter case the devices are usually single phase and are usually connected to the motor power wiring through a manual motor starter having "Manual-Off-Auto" provisions.
3. Control devices such as start-stop push buttons, thermostats, pressure switches, flow switches, relays, etc., generally represent the types of equipment associated with motor control wiring.
4. Motor control wiring is single phase and usually 120 volts. In some instances, the voltage will be the same as the motor power wiring. Generally, where the motor power wiring exceeds 120 volts, a control transformer is used to give a control voltage of 120 volts.
5. Temperature Control Wiring: The wiring associated with the operation of a motorized damper, solenoid valve or motorized valve, etc., either modulating or two-position, as opposed to wiring which directly powers or controls a motor used to drive equipment such as fans, pumps, etc.
    a. This wiring will be from a 120 volt source and may continue as 120 volt, or be reduced in voltage (24 volt) in which case a control transformer shall be furnished as part of the temperature control wiring.
6. Control Motor: An electric device used to operate dampers, valves, etc. It may be two-position or modulating. Conventional characteristics of such a motor are 24 volts, 60 cycles, 1 phase, although other voltages may be encountered.
7. Voltage is generally specified and scheduled as distribution voltage. Motor submittals may be based on utilization voltage if it corresponds to the correct distribution voltage.

Distribution/Nominal Voltage	Utilization Voltage
120	115
208	200
240	230
277	265
480	460

B. General:

1. The purpose of these Specifications is to outline the Electrical and Mechanical Contractor's responsibilities related to electrical work required for items such as temperature controls, mechanical equipment, fans, chillers, compressors and the like. The exact wiring requirements for much of the equipment cannot be determined until the systems have been selected and submittals reviewed. Therefore, the electrical drawings show only known wiring related to such items. All wiring not shown on the electrical drawings, but required for mechanical systems, is the responsibility of the Mechanical Contractor.
2. Where the drawings require the Electrical Contractor to wire between equipment furnished by the Mechanical Contractor, such wiring shall terminate at terminals provided in the equipment. The Mechanical Contractor shall provide complete electrical power/controls wiring diagrams and supervision to the Electrical Contractor and designate the terminal numbers for correct wiring.
3. All electrical work shall conform to the National Electrical Code. All provisions of the Electrical Specifications concerning wiring, protection, etc., apply to wiring provided by the Mechanical Contractor unless noted otherwise.
4. Control low (24V) and control line (120V) voltage wiring, conduit, and related switches and relays required for the automatic control and/or interlock of motors and equipment, including final connection, are to be furnished and installed under Divisions 21, 22 and 23. Materials and installation to conform to Class 1 or 2 requirements.
5. All Contractors shall establish utility elevations prior to fabrication and shall coordinate their material and equipment with other trades. When a conflict arises, priority is as follows:

    a. Light fixtures.
    b. Gravity flow piping, including steam and condensate.
    c. Electrical busduct.
    d. Sheet metal.
    e. Electrical cable trays, including access space.
    f. Sprinkler piping and other piping.
    g. Electrical conduits and wireway.

C. Mechanical Contractor's Responsibility:

1. Assumes responsibility for internal wiring of all equipment provided by the Mechanical Contractor, for example:

    a. Computer Room Air Conditioning Units.
    b. Condensate Return Stations.
    c. Package Air Handling Units.

2. Assumes all responsibility for the Temperature Control wiring, when the Temperature Control Contractor is a Subcontractor to the Mechanical Contractor.
3. Shall verify all existing equipment sizes and capacities where units are to be modified, moved or replaced. Contractor shall notify Architect/Engineer of any discrepancies <u>prior</u> to ordering new units or replacement parts, including replacements of equipment motors.
4. Temperature Control Subcontractor's Responsibility:

    a. Wiring of all devices needed to make the Temperature Control System functional.
    b. Verifying any control wiring on the electrical drawings as being by the Electrical Contractor. All wiring required for the Control System, but not shown on the electrical drawings, is the responsibility of the Temperature Control Subcontractor.
    c. Coordinating equipment locations (such as relays, transformers, etc.) with the Electrical Contractor, where wiring of the equipment is by the Electrical Contractor.

5. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

D. Electrical Contractor's Responsibility:

1. Provides all combination starters, manual starters and disconnect devices shown on the Electrical Drawings or indicated to be by the Electrical Contractor on the Mechanical Drawings or Specifications.
2. Installs and wires all remote control devices furnished by the Mechanical Contractor or Temperature Control Subcontractor when so noted on the Electrical Drawings.
3. Provides motor control and temperature control wiring, where so noted on the drawings.
4. Coordinate with the Mechanical Contractor for size of motors and/or other electrical devices involved with repair or replacement of existing equipment.
5. Furnishes, installs and connects all relays, etc., for automatic shutdown of certain fans upon actuation of the Fire Alarm System as indicated and specified in Division 28.
6. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

1.3 COORDINATION DRAWINGS

A. Definitions:

1. Coordination Drawings: A compilation of the pertinent layout and system drawings that show the sizes and locations, including elevations, of system components and required access areas to ensure that no two objects will occupy the same space.

   a. Mechanical trades shall include, but are not limited to, mechanical equipment, ductwork, fire protection systems, plumbing piping, medical gas systems, hydronic piping, steam and steam condensate piping, and any item that may impact coordination with other disciplines.
   b. Electrical trades shall include, but are not limited to, electrical equipment, conduit 1.5" and larger, conduit racks, cable trays, pull boxes, transformers, raceway, busway, lighting, ceiling-mounted devices, and any item that may impact coordination with other disciplines.
   c. Technology trades shall include, but are not limited to, technology equipment, racks, conduit 1.5" and larger, conduit racks, cable trays, ladder rack, pull boxes, raceway, ceiling-mounted devices, and any item that may impact coordination with other disciplines.
   d. Maintenance clearances and code-required dedicated space shall be included.
   e. The coordination drawings shall include all underground, underfloor, in-floor, in chase, and vertical trade items.

2. Spaces with open/cloud ceiling architecture shall indicate the overhead utilities and locate equipment as required to maintain clearance above lights. The intent for the installation is to maintain a maximum allowable vertical clearance and an organized/clean manner in the horizontal. Notify Architect/Engineer of the maximum clearance which can be maintained. Failure to comply will result in modifications with no cost to Owner.

   a. In cloud ceiling architecture, when open cabling/wire and/or cable tray crosses gaps between ceiling clouds and/or walls, cabling is to transition to conduits to span the gaps in order to conceal cabling from below.

3. The contractors shall use the coordination process to identify the proper sequence of installation of all utilities above ceilings and in other congested areas, to ensure an orderly and coordinated end result, and to provide adequate access for service and maintenance.

B. Participation:

1. The contractors and subcontractors responsible for work defined above shall participate in the coordination drawing process.
2. One contractor shall be designated as the Coordinating Contractor for purposes of preparing a complete set of composite electronic CAD coordination drawings that include all applicable trades, and for coordinating the activities related to this process. The Coordinating Contractor for this project shall be the Mechanical Contractor.

a. The Coordinating Contractor shall utilize personnel familiar with requirements of this project and skilled as draftspersons/CAD operators, competent to prepare the required coordination drawings.

3. Electronic CAD drawings shall be submitted to the Coordinating Contractor for addition of work by other trades. IMEG will provide electronic file copies of ventilation drawings for contractor's use if the contractor signs and returns an "Electronic File Transfer" waiver provided by IMEG. IMEG will not consider blatant reproductions of original file copies an acceptable alternative for coordination drawings.

C. Drawing Requirements:

1. The file format and file naming convention shall be coordinated with and agreed to by all contractors participating in the coordination process and the Owner.

a. Scale of drawings:

1) General plans: 1/4 Inch = 1'-0" (minimum).
2) Mechanical, electrical, communication rooms, and including the surrounding areas within 10 feet: 1/2 Inch = 1'-0" (minimum).
3) Shafts and risers: 1/2 Inch = 1'-0" (minimum).
4) Sections of shafts and mechanical and electrical equipment rooms: 1/4 Inch = 1'-0" (minimum).
5) Sections of congested areas: 1/2 Inch = 1'-0" (minimum).

2. Ductwork layout drawings shall be the baseline system for other components. Ductwork layout drawings shall be modified to accommodate other components as the coordination process progresses.
3. There may be more drawings required for risers, top and bottom levels of mechanical rooms, and shafts.
4. The minimum quantity of drawings will be established at the first coordination meeting and sent to the A/E for review. Additional drawings may be required if other areas of congestion are discovered during the coordination process.

D. General:

1. Coordination drawing files shall be made available to the A/E and Owner's Representative. The A/E will only review identified conflicts and give an opinion, but will not perform as a coordinator.
2. A plotted set of coordination drawings shall be available at the project site.
3. Coordination drawings are not shop drawings and shall not be submitted as such.
4. The contract drawings are schematic in nature and do not show every fitting and appurtenance for each utility. Each contractor is expected to have included in the bid sufficient fittings, material, and labor to allow for adjustments in routing of utilities made necessary by the coordination process and to provide a complete and functional system.
5. The contractors will not be allowed additional costs or time extensions due to participation in the coordination process.
6. The contractors will not be allowed additional costs or time extensions for additional fittings, reroutings or changes of duct size, that are essentially equivalent sizes to those shown on the drawings and determined necessary through the coordination process.
7. The A/E reserves the right to determine space priority of equipment in the event of spatial conflicts or interference between equipment, piping, conduit, ducts, and equipment provided by the trades.
8. Changes to the contract documents that are necessary for systems installation and coordination shall be brought to the attention of the A/E.
9. Access panels shall preferably occur only in gypsum board walls or plaster ceilings where indicated on the drawings.

a. Access to mechanical, electrical, technology, and other items located above the ceiling shall be through accessible lay-in ceiling tile areas.
b. Potential layout changes shall be made to avoid additional access panels.
c. Additional access panels shall not be allowed without written approval from the A/E at the coordination drawing stage.

d. Providing additional access panels shall be considered after other alternatives are reviewed and discarded by the A/E and the Owner's Representative.
e. When additional access panels are required, they shall be provided without additional cost to the Owner.

10. Complete the coordination drawing process and obtain sign off of the drawings by all contractors prior to installing any of the components.
11. Conflicts that result after the coordination drawings are signed off shall be the responsibility of the contractor or subcontractor who did not properly identify their work requirements, or installed their work without proper coordination.
12. Updated coordination drawings that reflect as-built conditions may be used as record documents.

1.4 QUALITY ASSURANCE

A. Contractor's Responsibility Prior to Submitting Pricing Data:

1. The Contractor is responsible for constructing complete and operating systems. The Contractor acknowledges and understands that the Contract Documents are a two-dimensional representation of a three-dimensional object, subject to human interpretation. This representation may include imperfect data, interpreted codes, utility guidelines, three-dimensional conflicts, and required field coordination items. Such deficiencies can be corrected when identified prior to ordering material and starting installation. The Contractor agrees to carefully study and compare the individual Contract Documents and report at once in writing to the Design Team any deficiencies the Contractor may discover. The Contractor further agrees to require each subcontractor to likewise study the documents and report at once any deficiencies discovered.
2. The Contractor shall resolve all reported deficiencies with the Architect/Engineer prior to awarding any subcontracts, ordering material, or starting any work with the Contractor's own employees. Any work performed prior to receipt of instructions from the Design Team will be done at the Contractor's risk.

B. Qualifications:

1. Only products of reputable manufacturers are acceptable.
2. All Contractors and subcontractors shall employ only workers skilled in their trades.

C. Compliance with Codes, Laws, Ordinances:

1. Conform to all requirements of the City of Springfield MO Codes, Laws, Ordinances and other regulations having jurisdiction.
2. Conform to all published standards of Missouri State University .
3. Conform to all State Codes.
4. Conform to Federal Act S.3874 requiring the reduction of lead in drinking water.
5. If there is a discrepancy between the codes and regulations and these specifications, the Architect/Engineer shall determine the method or equipment used.
6. If the Contractor notes, at the time of bidding, that any parts of the drawings or specifications do not comply with the codes or regulations, Contractor shall inform the Architect/Engineer in writing, requesting a clarification. If there is insufficient time for this procedure, Contractor shall submit with the proposal a separate price to make the system comply with the codes and regulations.
7. All changes to the system made after letting of the contract, to comply with codes or requirements of Inspectors, shall be made by the Contractor without cost to the Owner.
8. If there is a discrepancy between manufacturer's recommendations and these specifications, the manufacturer's recommendations shall govern.
9. All rotating shafts and/or equipment shall be completely guarded from all contact. Partial guards and/or guards that do not meet all applicable OSHA standards are not acceptable. Contractor is responsible for providing this guarding if it is not provided with the equipment supplied.

D. Permits, Fees, Taxes, Inspections:

1. Procure all applicable permits and licenses.

2. Abide by all laws, regulations, ordinances, and other rules of the State or Political Subdivision where the work is done, or as required by any duly constituted public authority.
3. Pay all charges for permits or licenses.
4. Pay all fees and taxes imposed by the State, Municipal and/or other regulatory bodies.
5. Pay all charges arising out of required inspections by an authorized body.
6. Pay all charges arising out of required contract document reviews associated with the project and as initiated by the Owner or authorized agency/consultant.
7. Where applicable, all fixtures, equipment and materials shall be listed by Underwriters' Laboratories, Inc. and approved by FM Global.

E. Utility Company Requirements:

1. Secure from the appropriate private or public utility company all applicable requirements.
2. Comply with all utility company requirements.
3. Make application for and pay for service connections, such as sewer and water and gas.
4. Make application for and pay for all meters and metering systems required by the utility company.

F. Examination of Drawings:

1. The drawings for the plumbing work are completely diagrammatic, intended to convey the scope of the work and to indicate the general arrangements and locations of equipment, outlets, etc., and the approximate sizes of equipment.
2. Contractor shall determine the exact locations of equipment and rough-ins, and the exact routing of pipes and ducts to best fit the layout of the job.
3. Scaling of the drawings is not sufficient or accurate for determining these locations.
4. Where job conditions require reasonable changes in indicated arrangements and locations, such changes shall be made by the Contractor at no additional cost to the Owner.
5. Because of the scale of the drawings, certain basic items, such as fittings, boxes, valves, unions, etc., may not be shown, but where required by other sections of the specifications or required for proper installation of the work, such items shall be furnished and installed.
6. If an item is either on the drawings or in the specifications, it shall be included in this contract.
7. Determination of quantities of material and equipment required shall be made by the Contractor from the documents. Where discrepancies arise between drawings, schedules and/or specifications, the greater number shall govern.
8. Where used in mechanical documents, the word "furnish" shall mean supply for use, the word "install" shall mean connect complete and ready for operation, and the word "provide" shall mean to supply for use and connect complete and ready for operation.

    a. Any item listed as furnished shall also be installed, unless otherwise noted.
    b. Any item listed as installed shall also be furnished, unless otherwise noted.

G. Field Measurements:

1. Verify all pertinent dimensions at the job site before ordering any materials or fabricating any supports, pipes or ducts.

H. Electronic Media/Files:

1. Construction drawings for this project have been prepared utilizing Revit.
2. Contractors and Subcontractors may request electronic media files of the contract drawings and/or copies of the specifications. Specifications will be provided in PDF format.
3. Upon request for electronic media, the Contractor shall complete and return a signed "Electronic File Transmittal" form provided by IMEG.
4. If the information requested includes floor plans prepared by others, the Contractor will be responsible for obtaining approval from the appropriate Design Professional for use of that part of the document.
5. The electronic contract documents can be used for preparation of shop drawings and as-built drawings only. The information may not be used in whole or in part for any other project.
6. The drawings prepared by IMEG for bidding purposes may not be used directly for ductwork layout drawings or coordination drawings.

7. The use of these CAD documents by the Contractor does not relieve them from their responsibility for coordination of work with other trades and verification of space available for the installation.
8. The information is provided to expedite the project and assist the Contractor with no guarantee by IMEG as to the accuracy or correctness of the information provided. IMEG accepts no responsibility or liability for the Contractor's use of these documents.

1.5 SUBMITTALS

A. Submittals shall be required for the following items, and for additional items where required elsewhere in the specifications or on the drawings.

1. Submittals List:

Referenced Specification Section	Submittal Item
22 05 00	Owner Training Agenda
22 05 13	Motors
22 05 16	Expansion Compensation
22 05 48	Vibration Isolation Equipment
22 05 50	Seismic Restraint Systems
22 09 00	Instrumentation
22 10 00	Plumbing Piping Systems and Valves
22 10 23	Natural Gas and Propane Piping Systems
22 10 30	Plumbing Specialties
22 11 23	Domestic Water Pumps
22 13 29	Sanitary Sewage Pumps
22 14 29	Sump Pumps
22 15 19	Compressed Air Systems
22 30 00	Plumbing Equipment
22 40 00	Plumbing Fixtures

B. General Submittal Procedures: In addition to the provisions of Division 1, the following are required:

1. Transmittal: Each transmittal shall include the following:

a. Date
b. Project title and number
c. Contractor's name and address
d. Division of work (e.g., plumbing, heating, ventilating, etc.)
e. Description of items submitted and relevant specification number
f. Notations of deviations from the contract documents
g. Other pertinent data

2. Submittal Cover Sheet: Each submittal shall include a cover sheet containing:

a. Date
b. Project title and number
c. Architect/Engineer
d. Contractor and subcontractors' names and addresses
e. Supplier and manufacturer's names and addresses
f. Division of work (e.g., plumbing, heating, ventilating, etc.)
g. Description of item submitted (using project nomenclature) and relevant specification number
h. Notations of deviations from the contract documents
i. Other pertinent data
j. Provide space for Contractor's review stamps

3. Composition:

   a. Submittals shall be submitted using specification sections and the project nomenclature for each item.
   b. Individual submittal packages shall be prepared for items in each specification section. All items within a single specification section shall be packaged together where possible. An individual submittal may contain items from multiple specifications sections if the items are intimately linked (e.g., pumps and motors).
   c. All sets shall contain an index of the items enclosed with a general topic description on the cover.

4. Content: Submittals shall include all fabrication, erection, layout, and setting drawings; manufacturers' standard drawings; schedules; descriptive literature, catalogs and brochures; performance and test data; electrical power criteria (e.g., voltage, phase, amps, horsepower, kW, etc.) wiring and control diagrams; Short Circuit Current Rating (SCCR); dimensions; shipping and operating weights; shipping splits; service clearances; and all other drawings and descriptive data of materials of construction as may be required to show that the materials, equipment or systems and the location thereof conform to the requirements of the contract documents.
5. Contractor's Approval Stamp:

   a. The Contractor shall thoroughly review and approve all shop drawings before submitting them to the Architect/Engineer. The Contractor shall stamp, date and sign each submittal certifying it has been reviewed.
   b. Unstamped submittals will be rejected.
   c. The Contractor's review shall include, but not be limited to, verification of the following:

      1) Only approved manufacturers are used.
      2) Addenda items have been incorporated.
      3) Catalog numbers and options match those specified.
      4) Performance data matches that specified.
      5) Electrical characteristics and loads match those specified.
      6) Equipment connection locations, sizes, capacities, etc. have been coordinated with other affected trades.
      7) Dimensions and service clearances are suitable for the intended location.
      8) Equipment dimensions are coordinated with support steel, housekeeping pads, openings, etc.
      9) Constructability issues are resolved (e.g., weights and dimensions are suitable for getting the item into the building and into place, sinks fit into countertops, etc.).

   d. The Contractor shall review, stamp and approve all subcontractors' submittals as described above.
   e. The Contractor's approval stamp is required on all submittals. Approval will indicate the Contractor's review of all material and a complete understanding of exactly what is to be furnished. Contractor shall clearly mark all deviations from the contract documents on all submittals. If deviations are not marked by the Contractor, then the item shall be required to meet all drawing and specification requirements.

6. Submittal Identification and Markings:

   a. The Contractor shall clearly mark each item with the same nomenclature applied on the drawings or in the specifications.
   b. The Contractor shall clearly indicate the size, finish, material, etc.
   c. Where more than one model is shown on a manufacturer's sheet, the Contractor shall clearly indicate exactly which item and which data is intended.
   d. All marks and identifications on the submittals shall be unambiguous.

7. Schedule submittals to expedite the project. Coordinate submission of related items.
8. Identify variations from the contract documents and product or system limitations that may be detrimental to the successful performance of the completed work.
9. Reproduction of contract documents alone is not acceptable for submittals.

10. Incomplete submittals will be rejected without review. Partial submittals will only be reviewed with prior approval from the Architect/Engineer.
11. Submittals not required by the contract documents may be returned without review.
12. The Architect/Engineer's responsibility shall be to review one set of shop drawing submittals for each product. If the first submittal is incomplete or does not comply with the drawings and/or specifications, the Contractor shall be responsible to bear the cost for the Architect/Engineer to recheck and handle the additional shop drawing submittals.
13. Submittals shall be reviewed and approved by the Architect/Engineer before releasing any equipment for manufacture or shipment.
14. Contractor's responsibility for errors, omissions or deviation from the contract documents in submittals is not relieved by the Architect/Engineer's approval.
15. Schedule shall allow for adequate time to perform orderly and proper review of submittals, including time for consultants and Owner if required, and resubmittals by Contractor if necessary, and to cause no delay in Work or in activities of Owner or other contractors.

    a. Allow at least two weeks for Architect's/Engineer's review and processing of each submittal.

16. Architect/Engineer reserves the right to withhold action on a submittal which, in the Architect/Engineer's opinion, requires coordination with other submittals until related submittals are received. The Architect/Engineer will notify the Contractor, in writing, when they exercise this right.

C. Electronic Submittal Procedures:

1. Distribution: Email submittals as attachments to all parties designated by the Architect/Engineer, unless a web-based submittal program is used.
2. Transmittals: Each submittal shall include an individual electronic letter of transmittal.
3. Format: Electronic submittals shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Submittals that are not legible will be rejected. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.
4. File Names: Electronic submittal file names shall include the relevant specification section number followed by a description of the item submitted, as follows. Where possible, include the transmittal as the first page of the PDF instead of using multiple electronic files.

    a. Submittal file name: 22 XX XX.description.YYYYMMDD
    b. Transmittal file name: 22 XX XX.description.YYYYMMDD

5. File Size: Files shall be transmitted via a pre-approved method. Larger files may require an alternative transfer method, which shall also be pre-approved.

1.6 EQUIPMENT SUPPLIERS' INSPECTION

A. The following equipment shall not be placed in operation until a competent installation and service representative of the manufacturer has inspected the installation and certified that the equipment is properly installed, adjusted and lubricated; that preliminary operating instructions have been given; and that the equipment is ready for operation:

1. Fire Seal Systems
2. Seismic Restraints and Equipment Bracing

B. Contractor shall arrange for and obtain supplier's on-site inspection(s) at proper time(s) to assure each phase of equipment installation and/or connection is in accordance with the manufacturer's instructions.

C. Submit copies of start-up reports to the Architect/Engineer and include copies of Owner's Operation and Maintenance Manuals.

1.7 PRODUCT DELIVERY, STORAGE, HANDLING & MAINTENANCE

A. Exercise care in transporting and handling to avoid damage to materials. Store materials on the site to prevent damage. Keep materials clean, dry and free from harmful conditions. Immediately remove any materials that become wet or that are suspected of becoming contaminated with mold or other organisms.

B. Keep all bearings properly lubricated and all belts properly tensioned and aligned.

C. Coordinate the installation of heavy and large equipment with the General Contractor and/or Owner. If the Mechanical Contractor does not have prior documented experience in rigging and lifting similar equipment, he/she shall contract with a qualified lifting and rigging service that has similar documented experience. Follow all equipment lifting and support guidelines for handling and moving.

D. Contractor is responsible for moving equipment into the building and/or site. Contractor shall review site prior to bid for path locations and any required building modifications to allow movement of equipment. Contractor shall coordinate the work with other trades.

1.8 NETWORK / INTERNET CONNECTED EQUIPMENT

A. These specifications may require certain equipment or systems to have network, Internet and/or remote access capability ("Network Capability"). Any requirement for Network Capability shall be interpreted only as a functional capability and is not to be construed as authority to connect or enable any Network Capability. Network Capability may only be connected or enabled with the express written consent of the Owner.

1.9 WARRANTY

A. Provide one-year warranty, unless otherwise noted, to the Owner for all fixtures, equipment, materials, and workmanship.

B. The warranty period for all work in this Division of the specifications shall commence on the date of final acceptance, unless a whole or partial system or any separate piece of equipment or component is put into use for the benefit of any party other than the installing contractor with prior written authorization. In this instance, the warranty period shall commence on the date when such whole system, partial system or separate piece of equipment or component is placed in operation and accepted in writing by the Owner.

C. Warranty requirements shall extend to correction, without cost to the Owner, of all Work found to be defective or nonconforming to the contract documents. The Contractor shall bear the cost of correcting all damage resulting from defects or nonconformance with contract documents.

1.10 INSURANCE

A. Contractor shall maintain insurance coverage as set forth in Division 0 of these specifications.

1.11 MATERIAL SUBSTITUTION

A. Where several manufacturers' names are given, the first manufacturer is the basis for job design and establishes the quality.

B. Equivalent equipment manufactured by the other listed manufacturers may be used. Contractor shall ensure that all items submitted by these other manufacturers meet all requirements of the drawings and specifications and fits in the allocated space. When using other listed manufacturers, the Contractor shall assume responsibility for any and all modifications necessary (including, but not limited to structural supports, electrical connections, piping and ductwork connections and arrangement, plumbing connections and rough-in, and regulatory agency approval, etc.) and coordinate such with other contractors.

C. Any material, article or equipment of other unnamed manufacturers which will adequately perform the services and duties imposed by the design and is of a quality equal to or better than the material, article or equipment identified by the drawings and specifications may be used if approval is secured in writing from the Architect/Engineer not later than ten days prior to the bid opening.

D. This Contractor assumes all costs incurred as a result of using the offered material, article or equipment, on the Contractor's part or on the part of other Contractors whose work is affected.

E. This Contractor may list voluntary add or deduct prices for alternate materials on the bid form. These items will not be used in determining the low bidder.

F. All material substitutions requested later than ten (10) days prior to bid opening must be listed as voluntary changes on the bid form.

1.12 PROJECT COMMISSIONING

A. The Contractor shall work with the Commissioning Agent (CxA) as described in Section 01 91 00 and 22 08 00 and provide all services as described in the Commissioning Plan.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 JOBSITE SAFETY

A. Neither the professional activities of the Architect/Engineer, nor the presence of the Architect/Engineer or the employees and subconsultants at a construction site, shall relieve the Contractor and other entity of their obligations, duties and responsibilities including, but not limited to, construction means, methods, sequence, techniques or procedures necessary for performing, superintending or coordinating all portions of the work of construction in accordance with the contract documents and any health or safety precautions required by any regulatory agencies. The Architect/Engineer and personnel have no authority to exercise any control over any construction contractor or other entity or their employees in connection with their work or any health or safety precautions. The Contractor is solely responsible for jobsite safety. The Architect/Engineer and the Architect/Engineer's consultants shall be indemnified and shall be made additional insureds under the Contractor's general liability insurance policy.

3.2 EXCAVATION, FILL, BACKFILL, COMPACTION

A. General:

1. Prior to the commencement of any excavation or digging, the Contractor shall verify all underground utilities with the regional utility locator. Provide prior notice to the locator before excavations. Contact information for most regional utility locaters can be found at the following website (https://call811.com/) or by calling 811.
2. The Contractor shall do all excavating, filling, backfilling and compacting associated with the work.

B. Excavation:

1. Make all excavations to accurate, solid, undisturbed earth, and to proper dimensions.
2. Where excavations are made in error below foundations, concrete of same strength as specified for the foundations or thoroughly compacted sand-gravel fill, as determined by the Architect/Engineer, shall be placed in such excess excavations. Place thoroughly compacted, clean, stable fill in excess excavations under slabs on grade, at the Contractor's expense.
3. Trim bottom and sides of excavations to grades required for foundations.
4. Protect excavations against frost and freezing.
5. Take care in excavating not to damage surrounding structures, equipment, or buried pipe. Do not undermine footing or foundation.
6. Perform all trenching in a manner to prevent cave-ins and risk to workers.
7. Where original surface is pavement or concrete, the surface shall be saw cut to provide clean edges and assist in the surface restoration.
8. Where satisfactory bearing soil for foundations is not found at the indicated levels, the Architect/Engineer or their representative shall be notified immediately, and no further work shall be done until further instructions are given by the Architect/Engineer or their representative.

C. Dewatering:

1. Contractor shall furnish, install, operate, and remove all dewatering pumps and pipes needed to keep trenches and pits free of water.

D. Underground Obstructions:

1. Known underground piping, foundations, and other obstructions in the vicinity of construction are shown on the drawings. Use great care in making installations near underground obstruction.
2. If objects not shown on the drawings are encountered, remove, relocate, or perform extra work as directed by the Architect/Engineer.

E. Fill and Backfilling:

1. Utilities Bedding: Lay underground utilities on minimum of 6"sand bedding or CA6 crushed stone. Compact bedding under utilities smooth, with no sharp edges protruding, to protect the utilities from puncture. Shape bedding to provide continuous support for bells, joints, and barrels of utilities and for joints and fittings.
2. Envelope around utilities to 6" above utilities: Place and compact sand or CA6 to a height of 6" over utilities in 6" layers. Each layer shall be placed, then carefully and uniformly tamped, to eliminate lateral or vertical displacement. After connection joints are made, any misalignment can be corrected by tamping backfill around the utilities.
3. Backfill from 6" above utilities to earthen grade: Place all backfill materials above the utilities in uniform layers not exceeding 6" deep. Each layer shall be placed, then carefully and uniformly tamped, to eliminate lateral or vertical displacement.
4. Backfill from 6" above utilities to below slabs or paved area: Where the fill and backfill will ultimately be under a building, floor or paving, each layer of backfill materials shall be compacted to 95% of the maximum density determined by AASHTO Designation T 99 or ASTM Designation D 698. Moisture content of soil at time of compaction shall not exceed plus or minus 2% of optimum moisture content determined by AASHTO T 99 or ASTM D 698 test.
5. Backfill Materials: Native soil materials may be used as backfill if approved by the Geotechnical Engineer. Backfill material shall be free of rock or gravel larger than 3" in any dimension and shall be free of debris, waste, frozen materials, vegetation, high void content, and other deleterious materials. Water shall not be permitted to rise in unbackfilled trenches.
6. Dispose of excess excavated earth as directed.
7. Backfill all trenches and excavations immediately after installing utilities or removal of forms, unless other protection is provided.
8. Around piers and isolated foundations and structures, backfill and fill shall be placed and consolidated simultaneously on all sides to prevent wedge action and displacement. Fill and backfill materials shall be spread in 6 inch uniform horizontal layers with each layer compacted separately to required density.

F. Surface Restoration:

1. Where trenches are cut through existing graded, planted, or landscaped areas, the areas shall be restored to the original condition. Replace all planting removed or damaged to its original condition. A minimum of 6 inches of topsoil shall be applied where disturbed areas are to be seeded or sodded.
2. Concrete or asphalt type pavement, seal coat, rock, gravel or earth surfaces removed or damaged shall be replaced with comparable materials and restored to original condition.

3.3 ARCHITECT/ENGINEER OBSERVATION OF WORK

A. The Contractor shall provide seven (7) calendar days' notice to the Architect/Engineer prior to:

1. Placing fill over underground and underslab utilities.
2. Covering exterior walls, interior partitions and chases.
3. Installing hard or suspended ceilings and soffits.

B. The Architect/Engineer will have the opportunity to review the installation and provide a written report noting deficiencies requiring correction. The Contractor's schedule shall account for these reviews and show them as line items in the approved schedule.

C. Above-Ceiling Final Observation

1. All work above the ceilings must be complete prior to the Architect/Engineer's review. This includes, but is not limited to:

a. Pipe insulation is installed and fully sealed.
b. Pipe wall penetrations are sealed.
c. Pipe identification and valve tags are installed.

2. In order to prevent the Above-Ceiling Final Observation from occurring too early, the Contractor shall review the status of the work and certify, in writing, that the work is ready for the Above-Ceiling Final Observation.
3. It is understood that if the Architect/Engineer finds the ceilings have been installed prior to this review and prior to 7 days elapsing, the Architect/Engineer may not recommend further payments to the contractor until such time as full access has been provided.

3.4 PROJECT CLOSEOUT

A. The following paragraphs supplement the requirements of Division 1.

B. Final Jobsite Observation:

1. In order to prevent the Final Jobsite Observation from occurring too early, the Contractor is required to review the completion status of the project and certify that the job is ready for the final jobsite observation.
2. Attached to the end of this section is a typical list of items that represent the degree of job completeness expected prior to requesting a review.
3. Upon Contractor certification that the project is complete and ready for a final observation, the Contractor shall sign the attached certification and return it to the Architect/Engineer so that the final observation can be scheduled.
4. It is understood that if the Architect/Engineer finds the job not ready for the final observation and that additional trips and observations are required to bring the project to completion, the costs incurred by the Architect/Engineer's additional time and expenses will be deducted from the Contractor's contract retainage prior to final payment at the completion of the job.

C. Before final payment is authorized, this Contractor must submit the following:

1. Operation and maintenance manuals with copies of approved shop drawings.
2. Record documents including marked-up or reproducible drawings and specifications.
3. A report documenting the instructions given to the Owner's representatives complete with the number of hours spent in the instruction. The report shall bear the signature of an authorized agent of This Contractor and shall be signed by the Owner's representatives.
4. Start-up reports on all equipment requiring a factory installation inspection or start-up.
5. Provide spare parts, maintenance, and extra materials in quantities specified in individual specification sections. Deliver to project site and place in location as directed; receipt by Architect/Engineer required prior to final payment approval.

3.5 OPERATION AND MAINTENANCE MANUALS

A. General:

1. Provide an electronic copy of the O&M manuals as described below for Architect/Engineer's review and approval. The electronic copy shall be corrected as required to address the Architect/Engineer's comments. Once corrected, electronic copies and paper copies shall be distributed as directed by the Architect/Engineer.
2. Approved O&M manuals shall be completed and in the Owner's possession prior to Owner's acceptance and at least 10 days prior to instruction of operating personnel.

B. Electronic Submittal Procedures:

1. Distribution: Email the O&M manual as attachments to all parties designated by the Architect/Engineer.
2. Transmittals: Each submittal shall include an individual electronic letter of transmittal.
3. Format: Electronic submittals shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Submittals that are not legible will be rejected. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.
4. File Names: Electronic submittal file names shall include the relevant specification section number followed by a description of the item submitted, as follows. Where possible, include the transmittal as the first page of the PDF instead of using multiple electronic files.
    a. O&M file name: O&M.div22.contractor.YYYYMMDD
    b. Transmittal file name: O&Mtransmittal.div22.contractor.YYYYMMDD
5. File Size: Files shall be transmitted via a pre-approved method. Larger files may require an alternative transfer method, which shall also be pre-approved.
6. Provide the Owner with an approved copy of the O&M manual on compact discs (CD), digital video discs (DVD), or flash drives with a permanently affixed label, printed with the title "Operation and Maintenance Instructions", title of the project and subject matter of disc/flash drive when multiple disc/flash drives are required.
7. All text shall be searchable.
8. Bookmarks shall be used, dividing information first by specification section, then systems, major equipment and finally individual items. All bookmark titles shall include the nomenclature used in the construction documents and shall be an active link to the first page of the section being referenced.

C. Paper Copy Submittal Procedures:

1. Once the electronic version of the manuals has been approved by the Architect/Engineer, 4 paper copies of the O&M manual shall be provided to the Owner. The content of the paper copies shall be identical to the corrected electronic copy.

2. Binder Requirements: The Contractor shall submit O&M manuals in heavy duty, locking three ring binders. Incorporate clear vinyl sheet sleeves on the front cover and spine for slip-in labeling. "Peel and stick" acceptable. Sheet lifters shall be supplied at the front of each notebook. The three-ring binders shall be 1/2" thicker than initial material to allow for future inserts. If more than one notebook is required, label in consecutive order. For example; 1 of 2, 2 of 2. No other form of binding is acceptable.
3. Binder Labels: Label the front and spine of each binder with "Operation and Maintenance Instructions", title of project, and subject matter.
4. Index Tabs: Divide information by specification section, major equipment, or systems using index tabs. All tab titling shall be clearly printed under reinforced plastic tabs. All equipment shall be labeled to match the identification in the construction documents.

D. Operation and Maintenance Instructions shall include:

1. Title Page: Include title page with project title, Architect, Engineer, Contractor, all subcontractors, and major equipment suppliers, with addresses, telephone numbers, website addresses, email addresses and point of contacts. Website URLs and email addresses shall be active links in the electronic submittal.
2. Table of Contents: Include a table of contents describing specification section, systems, major equipment, and individual items.
3. Copies of all final <u>approved</u> shop drawings and submittals. Include Architect's/Engineer's shop drawing review comments. Insert the individual shop drawing directly after the Operation and Maintenance information for the item(s) in the review form.
4. Copy of final approved test and balance reports.
5. Copies of all factory inspections and/or equipment startup reports.
6. Copies of warranties.
7. Schematic electrical power/controls wiring diagrams of the equipment that have been updated for field conditions. Field wiring shall have label numbers to match drawings.
8. Dimensional drawings of equipment.
9. Capacities and utility consumption of equipment.
10. Detailed parts lists with lists of suppliers.
11. Operating procedures for each system.
12. Maintenance schedule and procedures. Include a chart listing maintenance requirements and frequency.
13. Repair procedures for major components.
14. List of lubricants in all equipment and recommended frequency of lubrication.
15. Instruction books, cards, and manuals furnished with the equipment.
16. Owner and Contractor attendance list for domestic water systems operation, maintenance, and flushing training.

3.6 INSTRUCTING THE OWNER'S REPRESENTATIVES

A. Adequately instruct the Owner's designated representatives in the maintenance, care, and operation of all systems installed under this contract.

B. Provide verbal and written instructions to the Owner's representatives by FACTORY PERSONNEL in the care, maintenance, and operation of the equipment and systems.

C. The Owner has the option to make a video recording of all instructions. Coordinate schedule of instructions to facilitate this recording.

D. The instructions shall include:

1. Explanation of all system flow diagrams.
2. Maintenance of equipment.
3. Start-up procedures for all major equipment.
4. Explanation of seasonal system changes.
5. Explanation of Owner’s Responsibilities to operate, maintain, and flush domestic water system (i.e., ASHRAE Standard 188).

E. Notify the Architect/Engineer of the time and place for the verbal instructions to be given to the Owner's representative so a representative can attend if desired.

F. Minimum hours of instruction for each item shall be:

1. Domestic Hot Water System - 4 hours
2. All Domestic Water Systems operation, maintenance and flushing of all fixtures and dead legs - 8 hours
3. Domestic Water Pressure Booster System - 4 hours.
4. Water Softener, Filtration and/or Purification System - 4 hours
5. Domestic Water Supplemental Treatment System - 4 hours

G. The Contractor shall prepare a detailed, written training agenda and submit it to the Architect/Engineer a minimum of four weeks prior to the formal training for approval. The written agenda shall include specific training points within the items described above. For example: how to adjust setpoints, troubleshooting, proper start-up, proper shut-down, seasonal changes, draining, venting, changing filters, changing belts, etc. Failure to provide and follow an approved training agenda may result in additional training required at the expense of the Contractor.

H. Operating Instructions:

1. Contractor is responsible for all instructions to the Owner's representatives for the mechanical and control systems.
2. If the Contractor does not have staff that can adequately provide the required instructions the Contractor shall include in the bid an adequate amount to reimburse the Owner for the Architect/Engineer to perform these services.

3.7 SYSTEM STARTING AND ADJUSTING

A. The plumbing systems shall be complete and operating. System startup, testing, adjusting, and balancing to obtain satisfactory system performance is the responsibility of the Contractor. This includes calibration and adjustments of all controls, noise level adjustments and final adjustments as required.

B. Complete all manufacturer-recommended startup procedures and checklists to verify proper motor rotation, electrical power voltage is within equipment limitations, equipment controls maintain pressures and temperatures within acceptable ranges, all filters and protective guards are in-place, acceptable access is provided for maintenance and servicing, and equipment operation does not pose a danger to personnel or property.

C. Contractor shall adjust the plumbing systems and controls at season changes during the one year warranty period, as required, to provide satisfactory operation and to prove performance of all systems in all seasons.

D. All operating conditions and control sequences shall be tested during the start-up period. Test all interlocks, safety shutdowns, controls, and alarms.

E. The Contractor, subcontractors, and equipment suppliers shall have skilled technicians to ensure that all systems perform properly. If the Architect/Engineer is requested to visit the job site for trouble shooting, assisting in start-up, obtaining satisfactory equipment operation, resolving installation and/or workmanship problems, equipment substitution issues or unsatisfactory system performance, including call backs during the warranty period, through no fault of the design; the Contractor shall reimburse the Owner on a time and materials basis for services rendered at the Architect/Engineer's standard hourly rates in effect when the services are requested. The Contractor shall pay the Owner for services required that are product, installation or workmanship related. Payment is due within 30 days after services are rendered.

3.8 RECORD DOCUMENTS

A. The following paragraphs supplement Division 1 requirements.

B. Maintain at the job site a separate and complete set of plumbing drawings and specifications with all changes made to the systems clearly and permanently marked in complete detail.

C. Mark drawings to indicate revisions to piping size and location, both exterior and interior; including locations devices, requiring periodic maintenance or repair; actual equipment locations, dimensioned from column lines; actual inverts and locations of underground piping; concealed equipment, dimensioned from column lines; mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located; Change Orders; concealed control system devices.

D. Before completion of the project, a set of reproducible plumbing drawings will be given to the Contractor for transfer of all as-built conditions from the paper set maintained at the job site. All marks on reproducibles shall be clear and permanent.

E. Mark specifications to show approved substitutions; Change Orders, and actual equipment and materials used.

F. Record changes daily and keep the marked drawings available for the Architect/Engineer's examination at any normal work time.

G. Upon completing the job, and before final payment is made, give the marked-up drawings to the Architect/Engineer.

3.9 ADJUST AND CLEAN

A. Thoroughly clean all equipment and systems prior to the Owner's final acceptance of the project. Clean all foreign paint, grease, oil, dirt, labels, stickers, and other foreign material from all equipment.

B. Clean all areas where moisture is present. Immediately report any mold, biological growth, or water damage.

C. Remove all rust, scale, dirt, oils, stickers and thoroughly clean exterior of all exposed piping, hangers, and accessories.

D. Remove all rubbish, debris, etc., accumulated during construction from the premises.

3.10 SPECIAL REQUIREMENTS

A. Contractor shall coordinate the installation of all equipment, valves, dampers, operators, etc., with other trades to maintain clear access area for servicing.

B. All equipment shall be installed in such a way to maximize access to parts needing service or maintenance. Review the final field location, placement, and orientation of equipment with the Owner's designated representative prior to setting equipment.

C. Installation of equipment or devices without regard to coordination of access requirements and confirmation with the Owner's designated representative will result in removal and reinstallation of the equipment at the Contractor's expense.

3.11 IAQ MAINTENANCE FOR OCCUPIED FACILITIES UNDER CONSTRUCTION

A. Contractors shall make all reasonable efforts to prevent construction activities from affecting the air quality of the occupied areas of the building or outdoor areas near the building. These measures shall include, but not be limited to:

1. All contractors shall endeavor to minimize the amount of contaminants generated during construction. Methods to be employed shall include, but not be limited to:

   a. Minimizing the amount of dust generated.
   b. Reducing solvent fumes and VOC emissions.
   c. Maintain good housekeeping practices, including sweeping and periodic dust and debris removal. There should be no visible haze in the air.
   d. Protect stored on-site and installed absorptive materials from moisture damage.

2. Request that the Owner designate an IAQ representative.
3. Review and receive approval from the Owner's IAQ representative for all IAQ-related construction activities and negative pressure containment plans.
4. Inform the IAQ representative of all conditions that could adversely impact IAQ, including operations that will produce higher than normal dust production or odors.
5. Schedule activities that may cause IAQ conditions that are not acceptable to the Owner's IAQ representative during unoccupied periods.
6. Request copies of and follow all of the Owner's IAQ and infection control policies.
7. Unless no other access is possible, the entrance to construction site shall not be through the existing facility.
8. To minimize growth of infectious organisms, do not permit damp areas in or near the construction area to remain for over 24 hours.
9. In addition to the criteria above, provide measures as recommended in the SMACNA "IAQ Guidelines for Occupied Buildings Under Construction".

3.12 UTILITY REBATE

A. Submit utility rebate forms, where offered at project location, with rebate items completed. Rebate may include lighting, lighting controls, variable speed drives, heat pumps, package terminal A/C, air conditioners, chillers, water heaters, programmable thermostats, and motors.

   1. Contractor must submit notification of any value engineering or product substitution that will affect the utility rebate amount prior to approval.

END OF SECTION 22 05 00

SECTION 22 05 05 - PLUMBING DEMOLITION FOR REMODELING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Plumbing Demolition.

B. Cutting and Patching.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Materials and equipment shall be as specified in individual Sections.

PART 3 - EXECUTION

3.1 EXAMINATION

A. THE DRAWINGS ARE INTENDED TO INDICATE THE GENERAL SCOPE OF WORK AND DO NOT SHOW EVERY PIPE, DUCT, OR PIECE OF EQUIPMENT THAT MUST BE REMOVED. THE CONTRACTOR SHALL VISIT THE SITE AND VERIFY CONDITIONS PRIOR TO SUBMITTING A BID.

B. Where walls, ceilings, etc., are shown as being removed on general drawings, the Contractor shall remove all mechanical equipment, devices, fixtures, piping, ducts, systems, etc., from the removed area.

C. Where ceilings, walls, partitions, etc., are temporarily removed and replaced by others, This Contractor shall remove, store, and replace equipment, devices, fixtures, pipes, ducts, systems, etc.

D. Verify that abandoned utilities serve only abandoned equipment or facilities. Extend services to facilities or equipment that shall remain in operation following demolition.

E. Coordinate work with all other Contractors and the Owner. Schedule removal of equipment to avoid conflicts.

F. This Contractor shall verify all existing equipment sizes and capacities where equipment is scheduled to be replaced or modified, prior to ordering new equipment.

G. Bid submittal shall mean the Contractor has visited the project site and verified existing conditions and scope of work.

3.2 PREPARATION

A. Disconnect plumbing systems in walls, floors, and ceilings scheduled for removal.

B. Provide temporary connections to maintain existing systems in service during construction. When work must be performed on operating equipment, use personnel experienced in such operations.

C. Existing Plumbing System: Maintain service to all plumbing fixtures until new piping is installed. Obtain permission from Owner at least 48 hours before shutting down system for any reason. Make changeover to new piping with minimum outage. Do not disconnect any roof drainage piping until new piping is in place and operational.

3.3 DEMOLITION AND EXTENSION OF EXISTING MECHANICAL WORK

A. Demolish and extend existing plumbing work under provisions of Division 2 and this Section.

B. Remove, relocate, and extend existing installations to accommodate new construction.

C. Remove abandoned piping to source of supply and/or main lines.

D. Remove exposed abandoned pipes, including abandoned pipes above accessible ceilings. Cut pipes above ceilings, below floors and behind walls. Cap remaining lines. Repair building construction to match original. Remove all clamps, hangers, supports, etc. associated with pipe and duct removal.

E. Disconnect and remove mechanical devices and equipment serving equipment that has been removed.

F. Repair adjacent construction and finishes damaged during demolition and extension work.

G. Extend existing installations using materials and methods compatible with existing installations, or as specified.

H. Remove unused sections of domestic water piping back to mains and cap. Capped pipe shall be less than 2 feet from main to prevent "dead legs".

I. Temporarily cap all openings to the sanitary and vent system to prevent odor from entering the work area and building.

3.4 CUTTING AND PATCHING

A. This Contractor is responsible for all penetrations of existing construction required to complete the work of this project. Refer to Section 22 05 29 for additional requirements.

B. Penetrations in existing construction should be reviewed carefully prior to proceeding with any work.

C. Penetrations shall be neat and clean with smooth and/or finished edges. Core drill where possible for clean opening.

D. Repair existing construction as required after penetration is complete to restore to original condition. Use similar materials and match adjacent construction unless otherwise noted or agreed to by the Architect/Engineer prior to start of work.

E. Floor slab is post-tensioned. All penetrations shall be x-rayed prior to cutting and/or drilling to avoid any tension cables or utilities encased in floor construction.

F. Floor slabs may contain conduit systems. This Contractor is responsible for taking any measures required to ensure no conduits or other services are damaged. This includes x-ray or similar non-destructive means.

G. This Contractor is responsible for all costs incurred in repair, relocations, or replacement of any cables, conduits, or other services if damaged without proper investigation.

3.5 CLEANING AND REPAIR

A. Clean and repair existing materials and equipment which remain or are to be reused.

B. Clean all systems adjacent to project which are affected by the dust and debris caused by this construction.

C. PLUMBING ITEMS REMOVED AND NOT RELOCATED REMAIN THE PROPERTY OF THE OWNER. CONTRACTOR SHALL PLACE ITEMS RETAINED BY THE OWNER IN A LOCATION COORDINATED WITH THE OWNER. THE CONTRACTOR SHALL DISPOSE OF MATERIAL THE OWNER DOES NOT WANT TO REUSE OR RETAIN FOR MAINTENANCE PURPOSES.

3.6 SPECIAL REQUIREMENTS

A. Install temporary filter media over outside air intakes which are within 100 feet of the limits of construction or as noted on the drawings. This Contractor shall complete any cleaning required for existing systems which are affected by construction dust and debris.

B. Review locations of all new penetrations in existing floor slabs or walls. Determine construction type and review for possible interferences. Bring all concerns to the attention of the Architect/Engineer before proceeding.

C. All medical gas piping scheduled for removal, relocation, extension, and/or revision will require re-certification by an independent agency acceptable to the Owner and NFPA-99 requirements. All testing shall conform to NFPA-99.

END OF SECTION 22 05 05

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SECTION 22 05 13 - MOTORS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Single Phase and Three Phase Electric Motors.

1.2 SUBMITTALS

A. Submit shop drawings under provisions of Section 22 05 00. Include nominal efficiency and power factor for all premium efficiency motors. Efficiencies must meet or exceed the nominal energy efficiency levels presented below.

B. Submit shop drawings for all three phase motors.

C. Submit motor data with equipment when motor is installed by the manufacturer at the factory.

D. Submit shaft grounding rings or brushes or ceramic bearings for all motors as required.

1.3 DELIVERY, STORAGE, AND HANDLING

A. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weatherproof coverings. For extended outdoor storage, follow manufacturer's recommendations for equipment and motor.

1.4 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data including assembly drawings, bearing data including replacement sizes, and lubrication instructions.

1.5 QUALIFICATIONS

A. Manufacturer: Company specializing in the manufacture of commercial and industrial motors and accessories, with a minimum of three years documented manufacturing experience.

PART 2 - PRODUCTS

2.1 GENERAL CONSTRUCTION AND REQUIREMENTS

A. Refer to the drawings for required electrical characteristics. Voltage is generally specified and scheduled as distribution voltage. Motor submittals may be based on utilization voltage if it corresponds to the correct distribution voltage.

Distribution/Nominal Voltage	Utilization Voltage
120	115
208	200
240	230

277	265
480	460

B. Design motors for continuous operation in 40ºC environment, and for temperature rise in accordance with ANSI/NEMA MG 1 limits for insulation class, service factor, and motor enclosure type.

C. Explosion-Proof Motors: UL listed and labeled for the hazard classification shown on the drawing, with over-temperature protection.

D. Visible Nameplate: Indicating horsepower, voltage, phase, hertz, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, service factor, power factor, insulation class.

E. Electrical Connection: Boxes, threaded for conduit. For fractional horsepower motors where connection is made directly, provide conduit connection in end frame.

F. Unless otherwise indicated, motors 3/4 HP and smaller shall be single phase, 60 hertz, open drip-proof or totally enclosed fan-cooled type.

G. Unless otherwise indicated, motors 1 HP and larger shall be three phase, 60 hertz, squirrel cage type, NEMA Design Code B (low current in-rush, normal starting torque), open drip-proof or totally enclosed fan-cooled type.

H. Each contractor shall set all motors furnished by him.

I. All motors shall have a minimum service factor of 1.15.

J. All motors shall have ball or roller bearings with a minimum L-10 fatigue life of 150,000 hours in direct-coupled applications and 50,000 hours for belted applications. Belted rating shall be based on radial loads and pulley sizes called out in NEMA MG1-14.43.

K. Bearings shall be sealed type for 10 HP and smaller motors. Bearings shall be regreasable type for larger motors.

L. Aluminum end housings are not permitted on motors 15 HP or larger.

M. Motor Driven Equipment:

1. No equipment shall be selected or operate above 90% of its motor nameplate rating. Motor size may not be increased to compensate for equipment with efficiency lower than that specified.
2. If a larger motor than specified is required on equipment, the contractor supplying the equipment is responsible for all additional costs due to larger starters, wiring, etc.

N. Provide all belted motors with a means of moving and securing the motor to tighten belts. Motors over 2 HP shall have screw type tension adjustment. Motors over 40 HP shall have dual screw adjusters. Slide bases shall conform to NEMA standards.

O. Motors for pumps 1/12 HP or greater and less than 1 HP shall be electronically-commutated motors or shall have a minimum motor efficiency of 70% when rated in accordance with DOE 10 CFR 431. These motors shall also have the means to adjust motor speed for either balancing or remote control.

2.2 ELECTRICALLY COMMUTATED MOTORS (ECM)

A. Motor shall be variable speed, constant torque, brushless DC motor for direct-drive applications. Electronics shall be encapsulated for moisture protection and shall integral surge protection. Motor shall be pre-wired for specific voltage and phase.

B. Motor frame shall be NEMA 48; UL recognized components shall be provided for the motor construction.

C. All EC motors shall be a minimum of 85% efficient at all speeds.

D. Motors shall be permanently lubricated; utilize ball bearings to match with the connected driven equipment.

E. Provide motor with onboard motor control module. Motor speed shall be limited to provide electronic over current protection. Starter shall provide soft start to reduce inrush current and shall be controllable from 20% to 100% of full rated speed.

F. Operational mode shall be as scheduled and shall be one of the following:

1. Constant Flow
2. Constant Temperature
3. Constant Pressure

2.3 PREMIUM EFFICIENCY MOTORS (INCLUDING MOST 3-PHASE GENERAL PURPOSE MOTORS)

A. All motors, unless exempted by EPAct legislation that became federal law on December 19, 2010, shall comply with the efficiencies listed in that standard, which are reprinted below. These match the 2010 NEMA premium efficiency ratings. All ratings listed are nominal full load efficiencies, verified in accordance with IEEE Standard 112, Test Method B. Average expected (not guaranteed minimum) power factors shall also be at least the following:

	Full-Load Efficiencies %					
	Open Drip-Proof			Totally Enclosed Fan Cooled		
HP	1200 rpm	1800 rpm	3600 rpm	1200 rpm	1800 rpm	3600 rpm
1.0	82.5	85.5	77.0	82.5	85.5	77.0
1.5	86.5	86.5	84.0	87.5	86.5	84.0
2.0	87.5	86.5	85.5	88.5	86.5	85.5
3.0	88.5	89.5	85.5	89.5	89.5	86.5
5.0	89.5	89.5	86.5	89.5	89.5	88.5
7.5	90.2	91.0	88.5	91.0	91.7	89.5
10.0	91.7	91.7	89.5	91.0	91.7	90.2
15.0	91.7	93.0	90.2	91.7	92.4	91.0
20.0	92.4	93.0	91.0	91.7	93.0	91.0
25.0	93.0	93.6	91.7	93.0	93.6	91.7
30.0	93.6	94.1	91.7	93.0	93.6	91.7
40.0	94.1	94.1	92.4	94.1	94.1	92.4
50.0	94.1	94.5	93.0	94.1	94.5	93.0
60.0	94.5	95.0	93.6	94.5	95.0	93.6
75.0	94.5	95.0	93.6	94.5	95.4	93.6
100.0	95.0	95.4	93.6	95.0	95.4	94.1
125.0	95.0	95.4	94.1	95.0	95.4	95.0
150.0	95.4	95.8	94.1	95.8	95.8	95.0
200.0	95.4	95.8	95.0	95.8	96.2	95.4
250.0	95.4	95.8	95.0	95.8	96.2	95.8
300.0	95.4	95.8	95.4	95.8	96.2	95.8
350.0	95.4	95.8	95.4	95.8	96.2	95.8
400.0	95.8	95.8	95.8	95.8	96.2	95.8
450.0	96.2	96.2	95.8	95.8	96.2	95.8
500.0	96.2	96.2	95.8	95.8	96.2	95.8

B. Motor nameplate shall be noted with the above ratings.

2.4 MOTORS ON VARIABLE FREQUENCY DRIVES

A. All motors driven by VFDs shall be premium efficiency type.

B. Motors shall be designed for use with VFDs in variable torque applications with 1.15 service factor. Motors shall not be equipped with auxiliary blowers.

C. Motors driven by VFDs shall have Class F or H insulation and be designated by the motor manufacturer to be suitable for inverter duty service in accordance with NEMA MG 1 Section IV, "Performance Standards Applying to All Machines," Part 31 "Definite-Purpose Inverter-Fed Polyphase Motors.

D. All 480 volt motors driven by VFDs shall be provided with shaft grounding rings or grounding brushes or ceramic bearings as a means to protect bearings from adverse shaft currents.

1. Providing grounding rings internal to the motor housing is an acceptable solution, provided the motor is affixed with a label clearly indicating the presence of a grounding assembly. The grounding ring shall be listed for 40,000 hours of motor service and shall be accessible via the drive endplate. Motor shafts 2" and larger require shaft grounding on the drive end and the non-drive end. This Contractor shall ensure (via field observation and measurement) that the shaft is effectively grounded upon startup.
2. In addition to 480 volt motors driven by VFDs, the following critical motors shall also be equipped with shaft grounding rings or brushes or ceramic bearings:

   a. .

2.5 SHEAVES

A. All sheaves shall conform to NEMA Standard MG1-14.42, which lists minimum diameters and maximum overhangs. Locate motors to minimize overhang.

B. When replacing sheaves, use sheaves of at least the originally supplied sizes.

C. Contractor responsible for motor shall also be responsible for replacement sheaves. Coordinate with testing and balancing of the equipment.

PART 3 - EXECUTION

3.1 INSTALLATION

A. All rotating shafts and/or equipment shall be completely guarded from all contact. Partial guards and/or guards that do not meet all applicable OSHA standards are not acceptable. Contractor is responsible for providing this guarding if it is not provided with the equipment supplied.

B. For flexible coupled drive motors, mount coupling to the shafts in accordance with the coupling manufacturer's recommendations. Align shafts to manufacturer's requirements or within 0.002 inch per inch diameter of coupling hub.

C. For belt drive motors, mount sheaves on the appropriate shafts per manufacturer's instructions. Use a straight edge to check alignment of the sheaves. Reposition sheaves as necessary so the straight edge contacts both sheave faces squarely. After sheaves are aligned, loosen the adjustable motor base so the belt(s) can be added, and tighten the base so the belt tension is in accordance with the drive manufacturer's recommendations. Frequently check belt tension and adjust if necessary during the first day of operation and again after 80 hours of operation.

END OF SECTION 22 05 13

SECTION 22 05 16 - PLUMBING EXPANSION COMPENSATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Expansion Joints and Compensators.

B. Pipe Loops, Offsets, and Swing Joints.

1.2 SUBMITTALS

A. Submit shop drawings under provisions of Section 22 05 00.

B. Expansion joint shop drawings shall include maximum motion.

1.3 DESIGN CRITERIA

A. Unless noted otherwise, base expansion calculations on 50°F installation temperature to 140°F for domestic hot water, plus 30% safety factor.

PART 2 - PRODUCTS

2.1 EXPANSION JOINTS

A. Type EJ-1:

1. Multiple plies of 300 series stainless steel bellows.
2. Rated for 150 psi working pressure at 250°F and 100psi at 400°F.
3. Cycle life shall be at least 1,000 full range (compression and extension) cycles at rated stroke and 6,000 cycles at 1/2 rated stroke.
4. Axial motion shall be as scheduled on the drawings, but not less than 2" (compression plus extension).
5. Provide removable metal insulation shroud around the bellows.
6. Joints 2" or smaller in copper piping systems shall have all copper, brass or bronze construction with stainless steel bellows and union ends or sweat ends with unions added.

a. Manufacturers:

1) American BOA Type KH
2) Hyspan Type 8509
3) Flexonics Model HB
4) Metraflex Model HPMF
5) Keflex Series 7QT

7. Joints 2" or smaller in ferrous piping systems shall have steel bodies with union ends or male threaded ends with unions added.

a. Manufacturers:

1) American BOA Type B

2) Hyspan Type 8503
3) Flexonics Model H
4) Metraflex Model HP Keflex Series 7Q-MPT

8. Joints 2-1/2" or larger shall have 150 lb. forged steel flanges.

a. Manufacturers:

1) American BOA Model 3150FS or 3150FL
2) Hyspan Model 1501
3) RM Model X-Flex-150 Multiply
4) Keflex Series 311-1215
5) Metraflex Model MNLC

B. Type EJ-2:

1. Multiple plies of 300 series stainless steel bellows.
2. Rated for 300 psi working pressure at 800°F.
3. Cycle life shall be at least 1,000 full range (compression and extension) cycles at rated stroke and 6,000 cycles at 1/2 rated stroke.
4. Axial motion shall be as scheduled on the drawings, but not less than 2" (compression and extension).
5. Joints shall have 300 lb. flanges on each end.
6. Provide stainless steel inner liner.
7. Provide removable metal insulation shroud around the bellows.

a. Manufacturers:

1) American BOA Type FS3300
2) Flexonics
3) RM Model X-Flex-300 Multiply or Hyspan Model 1501

C. Type EJ-4:

1. Assembly consisting of two flexible connectors, two stainless steel flexible connectors, two 90° elbows, and a 180° return pipe. Unit shall be in the form of a pipe loop.
2. Connectors shall have corrugated stainless hose bodies with stainless steel braided casings.
3. Connectors shall be rated for 150 psi working pressure at 70°F and 100 psi at 800°F.
4. Sizes 2" and smaller shall have steel threaded connections.
5. Sizes 2-1/2" and larger shall have 150 lb. steel flanges.
6. Connectors shall be suitable for 1/2" permanent misalignment.

a. Manufacturer:

1) Metraflex Type ML

D. Type EJ-5:

1. Plastic storm, waste and vent expansion joint. Pipe within a pipe arrangement with 6” (+/-3”) total travel.
2. Connectors shall have EPDM (PVC pipe) or FKM (CPVC) O-ring seal used to seal telescoping sections.
3. Solvent weld or fused connections to match piping material specification.
4. Rated for up to 140°F (PVC pipe) or 180°F (CPVC).

a. Manufacturer:

1) Flexicraft P or CP

E. Alignment Guides:

1. Bolted semi-steel spider.
2. Bolted guiding cylinder with supporting legs welded to pipe support.
3. Sized to allow insulation to pass through the outer cylinder.

a. Manufacturers:

1) American BOA
2) Hyspan, Flexonics
3) Keflex
4) Metraflex

F. Concrete Thrust Blocks - Rods and Clamps:

1. Bends, offsets, tees, crosses, and dead ends, including flange and spigot pieces, shall be suitably rodded or clamped and blocked with concrete thrust blocks.
2. Rods shall be all thread type, galvanized steel conforming to ANSI B1.1, Class 2A FIT, USS National Coarse Thread, tensile strength 55/77 ksi, yield strength 36 ksi minimum.
3. Rods and clamps shall receive one field coat of asphaltum after installation.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Accomplish structural work and provide equipment required to control expansion and contraction of piping; including loops, offsets, swing joints, and expansion joints where required.

B. Rigidly anchor pipe to building structure where necessary. Provide pipe guides so all movement occurs along axis of pipe only.

C. Each expansion joint shall have either one anchor or two alignment guides on each side of it. Guides shall be located within 4 and 14 pipe diameters of the expansion joint or as recommended by the joint manufacturer.

D. Preset all expansion joints to allow for expected expansion from installation temperature to operating temperature.

END OF SECTION 22 05 16

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SECTION 22 05 29 - PLUMBING SUPPORTS AND ANCHORS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Hangers, Supports, and Associated Anchors.

B. Equipment Bases and Supports.

C. Sleeves and Seals.

D. Flashing and Sealing of Equipment and Pipe Stacks.

E. Cutting of Openings.

F. Escutcheon Plates and Trim.

1.2 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 22 05 00. Include plastic pipe manufacturers' support spacing requirements.

1.3 WORK FURNISHED BUT INSTALLED UNDER OTHER SECTIONS

A. Furnish sleeves and hanger inserts to General Contractor for placement into formwork.

PART 2 - PRODUCTS

2.1 SEISMIC RESTRAINTS

A. Refer to Section 22 05 50 for additional requirements for seismic restraints.

2.2 HANGER RODS

A. Hanger rods for single rod hangers shall conform to the following:

	Hanger Rod Diameter	
Pipe Size	Column #1	Column #2
2-1/2" and smaller	3/8"	3/8"
3" through 3-5/8"	3/8"	3/8"
4" and 5"	1/2"	1/2"
6"	3/4"	5/8"
8" through 12"	7/8"	3/4"

Column #1: Steel, cast iron, and glass pipe.
Column #2: Copper and plastic pipe.

Rods for double rod hangers may be reduced one size. Minimum rod diameter is 3/8 inches.

B. Hanger rods and accessories used in mechanical spaces or otherwise dry areas shall have ASTM B633 electro-plated zinc finish.

C. All hanger rods, nuts, washers, clevises, etc., in damp areas shall have ASTM A123 hot-dip galvanized finish applied after fabrication. This applies to the following areas:

2.3 PIPE AND STRUCTURAL SUPPORTS

A. General:

1. Pipe hangers, clamps, and supports shall conform to Manufacturers Standardization Society MSS SP-58, 69, 89, and 127 (where applicable).
2. On all insulated piping, provide at each support an insert of same thickness and contour as adjoining insulation, between the pipe and insulation jacket, to prevent insulation from sagging and crushing. Refer to insulation specifications for materials and additional information.

3. Copper piping located in an exposed area, including indirect waste piping in janitor's closets, shall use split ring standoff hangers for copper tubing. Support shall include plastic pipe insert similar to Unistrut Cush-A-Clamp, Hydra-Zorb, Erico Cushion Clamp or Cooper Vibra-Clamp. Use electro-galvanized or more corrosion resistant and threaded rod for floor applications. Use anchors applicable to the wall type with corrosion resistant threaded rod for wall applications.

a. Products:

1) Erico/M-Co Model #456
2) B-Line Fig. 3198HCT
3) Anvil Fig. CT138R
4) Nibco/Tolco Fig. 301CT

B. Vertical Supports:

1. Support and laterally brace vertical pipes at every floor level in multi-story structures, unless otherwise noted by applicable codes, but never at intervals over 15 feet Support vertical pipes with riser clamps installed below hubs, couplings, or lugs. Provide sufficient flexibility to accommodate expansion and contraction to avoid compromising fire barrier penetrations or stressing piping at fixed takeoff locations.

a. Products:

1) Cooper/B-Line Fig B3373 Series
2) Erico 510 Series
3) Nibco/Tolco Fig. 82

2. Cold Pipe: Place restrained neoprene mounts beneath vertical pipe riser clamps to prevent sweating of cold pipes. Select neoprene mounts based on the weight of the pipe to be supported. Insulate over mounts.

a. Products:

1) Mason RBA, RCA or RDA
2) Mason BR

3. Cold Pipe Alternative: Insulated pipe riser clamp with no thermal bridging between clamp and pipe; water repellant calcium silicate insulation material adhered inside the clamp; ASTM A653 galvanized steel clamp.

   a. Products:

      1) Pipeshields E100

4. Wall supports shall be used where vertical height of structure exceeds minimum spacing requirements. Install wall supports at same spacing as hangers or strut supports along vertical length of pipe runs. Wall supports shall be coordinated with the Structural Engineer.
5. Masonry Anchors: Fasten to concrete masonry units with expansion anchors or self-tapping masonry screws. For expansion anchors into hollow concrete block, use sleeve-type anchors designed for the specific application. Do not fasten in masonry joints. Do not use powder actuated fasteners, wooden plugs, or plastic inserts.

C. Hangers and Clamps:

1. Oversize all hangers, clamps, and supports on insulated piping to allow insulation and jacket to pass through unbroken. This applies to both hot and cold pipes.
2. Hangers in direct contact with bare copper pipe shall include plastic pipe insert similar to Unistrut Cush-A-Clamp, Hydra-Zorb, Erico Cushion Clamp or Cooper Vibra-Clamp within their temperature limits of -65°F to +275°F.
3. Vertical cold pipe drops and rough-ins to fixtures shall be supported by insulated pipe clamps to prevent thermal bridging and condensation.
4. On all insulated piping, provide a semi-cylindrical metallic shield and vapor barrier jacket.
5. Ferrous hot piping 4 inches and larger shall have steel saddles tack welded to the pipe at each support with a depth not less than specified for the insulation. Factory fabricated inserts may be used.

   a. Products:

      1) Anvil Fig. 160, 161, 162, 163, 164, 165
      2) Cooper/B-Line Fig. 3160, 3161, 3162, 3163, 3164, 3165.
      3) Erico Model 630, 631, 632, 633, 634, 635.
      4) Nibco/Tolco Fig. 260-1, 261-1 1/2, 262-2, 263-2 1/2, 264-3, 265-4

6. Unless otherwise indicated, hangers shall be as follows:

   a. Clevis Type:

      1) Service: Bare Metal Pipe, Rigid Plastic Pipe, Insulated Cold Pipe, Insulated Hot Pipe - 3 inches & Smaller
      2) Products: Bare Steel Plastic or Insulated Pipe:

         a) Anvil Fig. 260
         b) Cooper/B-Line Fig. 3100
         c) Erico Model 400
         d) Nibco/Tolco Fig. 1

      3) Products: Bare Copper Pipe:

         a) Cooper/B-Line Fig. B3100C
         b) Nibco/Tolco Fig. 81PVC

   b. Roller Type:

      1) Service: Insulated Hot Pipe - 4 inches and Larger

2) Products: 4" through 6":

a) Anvil Fig. 181, 271
b) Cooper/B-Line Fig. 3110, 3117
c) Erico Model 610
d) Nibco/Tolco Fig. 324, 327

3) Products: 8" and Above:

a) Anvil Fig. 171, 271
b) Cooper/B-Line Fig. 3114, 3117
c) Erico Model 605
d) Nibco/Tolco Fig. 322, 327

c. Adjustable Swivel Ring Type:

1) Service: Bare Metal Pipe - 4 inches and Smaller
2) Bare Steel Pipe:

a) Anvil Fig. 69
b) Cooper/B-Line Fig. B3170NF
c) Erico Model FCN
d) Nibco/Tolco Fig. 200

3) Bare Copper Pipe:

a) Cooper/B-Line Fig. B3170CTC
b) Erico 102A0 Series
c) Nibco/Tolco Fig. 203

7. Support may be fabricated from U-channel strut or similar shapes. Piping less than 4" in diameter shall be secured to strut with clamps of proper design and capacity as required to maintain spacing and alignment. Strut shall be independently supported from hanger drops or building structure. Size and support shall be per manufacturer's installation requirements for structural support of piping. Clamps shall not interrupt piping insulation.

a. Strut used in mechanical spaces or otherwise dry areas shall have ASTM B633 electro-plated zinc finish.
b. Strut used in damp areas listed in hanger rods shall have ASTM A123 hot-dip galvanized finish applied after fabrication.

8. Unless otherwise indicated, pipe supports for use with struts shall be as follows:

a. Clamp Type:

1) Service: Bare Metal Pipe, Rigid Plastic Pipe, Insulated Cold Pipe, Insulated Hot Pipe - 3 inches and smaller
2) Clamps in direct contact with copper pipe shall include plastic pipe insert similar to Unistrut Cush-A-Clamp, Hydra-Zorb, Erico Cushion Clamp or Cooper Vibra-Clamp.
3) Pipes subject to expansion and contraction shall have clamps oversized to allow limited pipe movement.
4) Bare Steel, Plastic or Insulated Pipe:

a) Unistrut Fig. P1100 or P2500
b) Cooper/B-Line Fig. B2000 or B2400
c) Nibco/Tolco Fig. A-14 or 2STR

5) Bare Copper Pipe:

a) Cooper/B-Line Fig. BVT

b. Roller Type:

1) Service: Insulated Hot Pipe - 4 inches and larger.
2) Products: 4" through 6":

a) Unistrut Fig. P2474
b) Cooper/B-Line Fig. B218
c) Nibco/Tolco Fig. ROL-12

3) Products: 8" and Above:

a) Unistrut Fig. P2474-1
b) Cooper/B-Line Fig. B219
c) Nibco/Tolco Fig. ROL-13

D. Upper (Structural) Attachments:

1. Unless otherwise shown, upper attachments for hanger rods or support struts shall be as follows:

a. Steel Structure Clamps: C-Type Wide Flange Beam Clamps (for use on top and/or bottom of wide flanges. Not permitted for use with bar-joists.):

1) Products:

a) Anvil Fig. 92
b) Cooper/B-Line Fig. B3033/B3034
c) Erico Model 300
d) Nibco/Tolco 68

b. Steel Structure Clamps: Scissor Type Beam Clamps (for use with bar-joists and wide flange):

1) Products:

a) Anvil Fig. 228, 292
b) Cooper/B-Line Fig. B3054
c) Erico Model 360
d) Nibco/Tolco Fig. 329

c. Concentrically Loaded Open Web Joist Hangers (for use with bar joists):

1) Products:

a) MCL. M1, M2 or M3

d. Concrete: Concrete Inserts, Single Rod Galvanized:

1) Products:

a) Anvil Fig. 282
b) Cooper/B-Line Fig. B3014
c) Erico Model 355
d) Nibco/Tolco Fig. 310

e. Concrete: Concrete Inserts, Continuous Strip Galvanized:

1) Products:

a) Unistrut Corp P3200 Series

b) Cooper/B-Line Fig. B22-J
c) Erico CONCT

f. Concrete Anchors: Fasten to concrete using cast-in or post-installed anchors designed per the requirements of Appendix D of ACI 318-11. Post-installed anchors shall be qualified for use in cracked concrete by ACI-355.2.
g. Masonry Anchors: Fasten to concrete masonry units with expansion anchors or self-tapping masonry screws. For expansion anchors into hollow concrete block, use sleeve-type anchors designed for the specific application. Do not fasten in masonry joints. Do not use powder actuated fasteners, wooden plugs, or plastic inserts.
h. Steel Structure Welding:

1) Unless otherwise noted, hangers, clips, and auxiliary support steel may be welded in lieu of bolting, clamping, or riveting to the building structural frame. Take adequate precautions during all welding operations for fire prevention and protecting walls and ceilings from smoke damage.

2.4 FOUNDATIONS, BASES, AND SUPPORTS

A. Basic Requirements:

1. Furnish and install foundations, bases, and supports (not specifically indicated on the Drawings or in the Specifications of either the General Construction or Mechanical work as provided by another Contractor) for mechanical equipment.
2. All concrete foundations, bases and supports, shall be reinforced. All steel bases and supports shall receive a prime coat of zinc chromate or red metal primer. After completion of work, give steel supports a final coat of gray enamel.

B. Concrete Bases (Housekeeping Pads):

1. Refer to Section 22 05 50 for additional requirements for concrete bases in seismic applications.
2. Unless shown otherwise on the drawings, concrete bases shall be nominal 4 inches thick and shall extend 3 inches on all sides of the equipment (6 inches larger than factory base).
3. Where a base is less than 12 inches from a wall, extend the base to the wall to prevent a "dirt-trap".
4. Concrete materials and workmanship required for the Contractor's work shall be provided by the Contractor. Materials and workmanship shall conform to the applicable standards of the Portland Cement Association. Reinforce with 6"x6", W1.4-W1.4 welded wire fabric. Concrete shall withstand 3,000 pounds compression per square inch at 28 days.
5. Equipment requiring bases is as follows:

a. Expansion Tank
b. Day Tank
c. Heat Exchanger
d. Pump
e. Tank
f. Water Heater
g. Water Softener

C. Supports:

1. Provide sufficient clips, inserts, hangers, racks, rods, and auxiliary steel to securely support all suspended material, equipment and conduit without sag.
2. Hang heavy equipment from concrete floors or ceilings with Architect/Engineer-approved concrete inserts, furnished and installed by the Contractor whose work requires them, except where indicated otherwise.

D. Grout:

1. Grout shall be non-shrinking premixed (Master Builders Company "Embecco"), unless otherwise indicated on the drawings or approved by the Architect/Engineer.
2. Use Mix No. 1 for clearances of 1" or less, and Mix No. 2 for all larger clearances.
3. Grout under equipment bases, around pipes, at pipe sleeves, etc., and where shown on the drawings.

2.5 OPENINGS IN FLOORS, WALLS AND CEILINGS

A. Exact locations of all openings for the installation of materials shall be determined by the Contractor and given to the General Contractor for installation or construction as the structure is built.

B. Coordinate all openings with other Contractors.

C. Hire the proper tradesman and furnish all labor, material and equipment to cut openings in or through existing structures, or openings in new structures that were not installed, or additional openings. Repair all spalling and damage to the satisfaction of the Architect/Engineer. Make saw cuts before breaking out concrete to ensure even and uniform opening edges.

D. Said cutting shall be at the complete expense of each Contractor. Failure to coordinate openings with other Contractors shall not exempt the Contractor from providing openings at Contractor's expense.

E. Do not cut structural members without written approval of the Architect or Structural Engineer.

F. Exposed Housing Penetrations: Seal pipes with surface temperature below 150°F, penetrating housings with conical stepped, white silicone, EPDM or neoprene pipe flashings and stainless steel clamps equal to Portals Plus Pipe Boots or Pipetite.

2.6 ROOF PENETRATIONS

A. Roof Curb Enclosure: Provide weatherproof roof curb and enclosure for pipe penetrations. Refer to drawings for details.

B. Conical Pipe Boot: Seal pipes with surface temperature below 150°F penetrating single-ply roofs with conical stepped, UV-resistant silicone, EPDM or neoprene pipe flashings and stainless steel clamps equal to Portals Plus Pipe Boots or Pipetite. Color: White shall match roofing membrane.

C. Break insulation only at the clamp for pipes between 60°F and 150°F. Seal outdoor insulation edges watertight.

2.7 SLEEVES AND LINTELS

A. Each Contractor shall provide sleeves and lintels for all duct and pipe openings required for the Contractor's work in masonry walls and floors, unless specifically shown as being by others.

B. Fabricate all sleeves from standard weight black steel pipe or as indicated on the drawings. Provide continuous sleeve. Cut or split sleeves are not acceptable.

C. Fabricate all lintels for masonry walls from structural steel shapes or as indicated on the drawings. Have all lintels approved by the Architect or Structural Engineer.

D. Sleeves through the floors on exposed risers shall be flush with the ceiling, with planed squared ends extending 1" above the floor in unfinished areas, and flush with the floor in finished areas.

E. Sleeves shall not penetrate structural members or masonry walls without approval from the Structural Engineer. Sleeves shall then comply with the Architect/Engineer's design.

F. Openings through unexcavated floors and/or foundation walls below the floor shall have a smooth finish with sufficient annular space around material passing through opening so slight settling will not place stress on the material or building structure.

G. Install all sleeves concentric with pipes. Secure sleeves in concrete to wood forms. This Contractor is responsible for sleeves dislodged or moved when pouring concrete.

H. Where pipes rise through concrete floors that are on earthen grade, provide 3/4" resilient expansion joint material (e.g., foam, rubber, asphalt-coated fiber, bituminous-impregnated felt, or cork) wrapped around the pipe, the full depth of concrete, at the point of penetration. Secure to prevent shifting during concrete placement and finishing.

I. Size sleeves large enough to allow expansion and contraction movement. Provide continuous insulation wrapping.

J. Wall Seals ("Link-Seals"):

1. Where shown on the drawings, pipes passing through walls, ceilings, or floors shall have their annular space (sleeve or drilled hole - not tapered hole made with knockout plug) sealed by properly sized sealing elements consisting of a synthetic rubber material compounded to resist aging, ozone, sunlight, water and chemical action.
2. Sleeves, if used, shall be standard weight steel with primed finish and waterstop/anchor continuously welded to sleeve. If piping carries only fluids below 120°F, sleeves may be thermoplastic with integral water seal and textured surface.
3. Sleeves shall be at least 2 pipe sizes larger than the pipes.
4. Pressure shall be maintained by stainless steel bolts and other parts. Pressure plates may be of composite material for Models S and OS.
5. Sealing element shall be as follows:

		Element	
Model	Service	Material	Temperature Range
S	Standard (Stainless)	EPDM	-40°F to 250°F
T	High/Low Temperature (Steam)	Silicone	-67°F to 400°F
T	Fire Seals (1 hour)	Silicone	-67°F to 400°F
FS	Fire Seals (3 hours)	Silicone	-67°F to 400°F
OS	Oil Resistant/Stainless	Nitrile	-40°F to 210°F

6. Manufacturers:

a. Thunderline Corporation "Link-Seals"
b. O-Z/Gedney Company
c. Calpico, Inc.
d. Innerlynx
e. Metraflex Company (cold service only)

2.8 ESCUTCHEON PLATES AND TRIM

A. Fit escutcheons to all insulated or uninsulated exposed pipes passing through walls, floors, or ceilings of finished rooms.

B. Escutcheons shall be heavy gauge, cold rolled steel, copper coated under a chromium plated finish, heavy spring clip, rigid hinge and latch.

C. Install galvanized steel (unless otherwise indicated) trim strip to cover vacant space and raw construction edges of all rectangular openings in finished rooms. This includes pipe openings.

2.9 PIPE PENETRATIONS

A. Seal all pipe penetrations. Seal non-rated walls and floor penetrations with grout or caulk. Backing material may be used.

B. Seal fire rated wall and floor penetrations with fire seal system as specified.

2.10 PIPE ANCHORS

A. Provide all items needed to allow adequate expansion and contraction of all piping. All piping shall be supported, guided, aligned, and anchored as required.

B. Repair all piping leaks and associated damage. Pipes shall not rub on any part of the building.

2.11 FINISH

A. Prime coat exposed steel hangers and supports. Hangers and supports in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

PART 3 - EXECUTION

3.1 PLUMBING SUPPORTS AND ANCHORS

A. General Installation Requirements:

1. Install all items per manufacturer's instructions.
2. Coordinate the location and method of support of piping systems with all installations under other Divisions and Sections of the Specifications.
3. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.
4. Supports shall extend directly to building structure. Do not support piping from duct hangers unless coordinated with sheet metal contractor prior to installation. Do not allow lighting or ceiling supports to be hung from piping supports.

B. Supports Requirements:

1. Where building structural steel is fireproofed, all hangers, clamps, auxiliary steel, etc., which attach to it shall be installed prior to application of fireproofing. Repair all fireproofing damaged during pipe installation.
2. Set all concrete inserts in place before pouring concrete.
3. Furnish, install and prime all auxiliary structural steel for support of piping systems that are not shown on the Drawings as being by others.
4. Install hangers and supports complete with lock nuts, clamps, rods, bolts, couplings, swivels, inserts and required accessories.
5. Hangers for horizontal piping shall have adequate means of vertical adjustment for alignment.

C. Pipe Requirements:

1. Support all piping and equipment, including valves, strainers, traps and other specialties and accessories to avoid objectionable or excessive stress, deflection, swaying, sagging or vibration in the piping or building structure during erection, cleaning, testing and normal operation of the systems.
2. Do not, however, restrain piping to cause it to snake or buckle between supports or to prevent proper movement due to expansion and contraction.

3. Support piping at equipment and valves so they can be disconnected and removed without further supporting the piping.
4. Piping shall not introduce strains or distortion to connected equipment.
5. Parallel horizontal pipes may be supported on trapeze hangers made of structural shapes and hanger rods; otherwise, pipes shall be supported with individual hangers.
6. Trapeze hangers may be used where ducts interfere with normal pipe hanging.
7. Provide additional supports where pipe changes direction, adjacent to flanged valves and strainers, at equipment connections and heavy fittings.
8. Provide at least one hanger adjacent to each joint in grooved end steel pipe with mechanical couplings.

D. Provided the installation complies with all loading requirements of truss and joist manufacturers, the following practices are acceptable:

1. Loads of 100 lbs. or less may be attached anywhere along the top or bottom chords of trusses or joists with a minimum 3' spacing between loads.
2. Loads greater than 100 lbs. must be hung concentrically and may be hung from top or bottom chord, provided one of the following conditions is met:

a. The hanger is attached within 6" from a web/chord joint.
b. Additional L2x2x1/4 web reinforcement is installed per manufacturer's requirements.

3. It is prohibited to cantilever a load using an angle or other structural component that is attached to a truss or joist in such a fashion that a torsional force is applied to that structural member.
4. If conditions cannot be met, coordinate installation with truss or joist manufacturer and contact Architect/Engineer.

E. After piping and insulation installation are complete, cut hanger rods back at trapeze supports so they do not extend more than 3/4" below bottom face of lowest fastener and blunt any sharp edges.

F. Do not exceed 25 lbs. per hanger and a minimum spacing of 2'-0" on center when attaching to metal roof decking (limitation not required with concrete on metal deck). This 25 lbs. load and 2'-0" spacing include adjacent electrical and architectural items hanging from deck. If the hanger restrictions cannot be achieved, supplemental framing off steel framing will need to be added.

G. Do not exceed the manufacturer's recommended maximum load for any hanger or support.

H. Steel/Concrete Structure: Spacing of hangers shall not exceed the compressive strength of the insulation inserts, and in no case shall exceed the following:

1. Steel and Fiberglass (Std. Weight or Heavier - Liquid Service):

a. Maximum Spacing:

1) 1-1/4" & under: 7'-0"
2) 1-1/2": 9'-0"
3) 2": 10'-0"
4) 2-1/2": 11'-0"
5) 3": 12'-0"
6) 4" & larger: 12'-0"

2. Steel (Std. Weight or Heavier - Vapor Service):

a. Maximum Spacing:

1) 1-1/4" and under: 9'-0"
2) 1-1/2": 12'-0"
3) 2" & larger: 12'-0"

3. Hard Drawn Copper & Brass (Liquid Service):

    a. Maximum Spacing:

        1) 3/4" and under: 5'-0"
        2) 1": 6'-0"
        3) 1-1/4": 7'-0"
        4) 1-1/2" 8'-0"
        5) 2": 8'-0"
        6) 2-1/2": 9'-0"
        7) 3": 10'-0"
        8) 4": 12'-0"
        9) 6": 12'-0"

4. Hard Drawn Copper & Brass (Vapor Service):

    a. Maximum Spacing:

        1) 3/4" & under: 7'-0"
        2) 1": 8'-0"
        3) 1-1/4": 9'-0"
        4) 1-1/2": 10'-0"
        5) 2": 11'-0"
        6) 2-1/2" & larger: 12'-0"

5. Plastic Pipe:

    a. Hangers shall be spaced based on the piping system manufacturer's instructions or, if no system instructions are available, space hangers at 4'-0" maximum centers.

I. Installation of hangers shall conform to MSS SP-58, 69, 89 and the applicable Plumbing Code.

END OF SECTION 22 05 29

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SECTION 22 05 48 - PLUMBING VIBRATION ISOLATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Bases.

B. Vibration Isolation.

C. Flexible Connectors.

1.2 SUBMITTALS

A. Submit shop drawings per Section 22 05 00 and the Vibration Isolation Submittal Form at the end of this section.

B. Vibration isolation submittals may be included with equipment being isolated, but must comply with this section.

C. Base submittals shall include equipment served, construction, coatings, weights, and dimensions.

D. Isolator submittals shall include:

1. Equipment served
2. Type of Isolator
3. Load in Pounds per Isolator
4. Recommended Maximum Load for Isolator
5. Spring Constants of Isolators (for Spring Isolators)
6. Load vs. Deflection Curves (for Neoprene Isolators)
7. Specified Deflection
8. Deflection to Solid (at least 150% of calculated deflection)
9. Loaded (Operating) Deflection
10. Free Height
11. Loaded Height
12. Kx/Ky (horizontal to vertical stiffness ratio - for spring isolators)
13. Materials and Coatings
14. Spring Diameters

E. Make separate calculations for each isolator on equipment where the load is not equally distributed.

F. Flexible connector shop drawings shall include overall face-to-face length and all specified properties.

G. Submit certification that equipment, accessories, and components will withstand seismic forces defined in Section 22 05 50. Include the following:

1. Basis for Certification: Indicate whether certification is based on actual test of assembled components or on calculation.

   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

PART 2 - PRODUCTS

2.1 BASIC CONSTRUCTION AND REQUIREMENTS

A. Vibration isolation for this project is subject to seismic restraint requirements of Section 22 05 50.

B. Vibration isolators shall have either known undeflected heights or other markings so deflection under load can be verified.

C. All isolators shall operate in the linear portion of their load versus deflection curve. The linear portion of the deflection curve of all spring isolators shall extend 50% beyond the calculated operating deflection (e.g., 3” for 2" calculated deflection). The point of 50% additional deflection shall not exceed the recommended load rating of the isolator.

D. The lateral to vertical stiffness ratio (Kx/Ky) of spring isolators shall be between 0.8 and 2.0.

E. All neoprene shall have UV resistance sufficient for 20 years of outdoor service.

F. All isolators shall be designed or treated for corrosion resistance. Steel bases shall be cleaned of welding slag and primed for interior use, and hot dip galvanized after fabrication for exterior use. All bolts and washers over 3/8” diameter located outdoors shall be hot dip galvanized per ASTM A153. All other bolts, nuts and washers shall be zinc electroplated. All ferrous portions of isolators, other than springs, for exterior use shall be hot dip galvanized after fabrication. Outdoor springs shall be neoprene dipped or hot dip galvanized. All damage to coatings shall be field repaired with two coats of zinc rich coating.

G. Equip all mountings used with structural steel bases with height-saving brackets. Bottoms of the brackets shall be 1-1/2” to 2-1/2" above the floor or housekeeping pad, unless shown otherwise on the drawings. Steel bases shall have at least four points of support.

H. Provide motor slide rails for belt-driven equipment per Section 22 05 13.

I. All isolators, except M1, shall have provision for leveling.

J. All components in contact with potable water shall be lead free per Federal Act S.3874, Reduction of Lead in Drinking Water Act and NSF/ANSI-61 Low Lead Requirements for Drinking Water.

2.2 MOUNTINGS

A. Type M3:

1. Free standing, laterally stable spring isolators without housings and complete with 1/4" neoprene friction pads.
2. Units shall have bolt holes but need not be bolted down unless called for or needed to prevent movement. If bolted down, prevent short circuiting with neoprene bushings and washers between bolts and isolators. Bolt holes shall not be within the springs.
3. All mountings shall have leveling bolts.

    a. Manufacturers:

        1) Mason "SLFH"
        2) Kinetics "FDS"
        3) Amber/Booth "SW-3, 4”, 5" or 6"
        4) Vibration Eliminator Co. "OST".

2.3 HANGERS

A. Type H1:

1. Vibration hangers shall consist of a double-deflection neoprene element with a projecting bushing or oversized opening to prevent steel-to-steel contact.
2. Static deflection shall be at least 0.15” at calculated load and 0.35" at maximum rated load.
3. Provide hangers with end connections as required for hanging ductwork or piping.

    a. Manufacturers:

        1) Mason "HD"
        2) Kinetics "RH"
        3) Aeroflex "RHD"
        4) Vibration Eliminator Co. "IC/3C/3CTD"
        5) Vibro Acoustics "RH"

B. Type H2:

1. Vibration hangers shall contain a steel spring in a neoprene cup with a grommet to prevent short circuiting the hanger rod.
2. The cup shall have a steel washer to distribute load on the neoprene and prevent its extrusion.
3. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30° arc before contacting the grommet and short circuiting the spring.
4. Provide end connections for hanging ductwork or piping.

    a. Manufacturers:

        1) Mason "30"
        2) Kinetics "SRH"
        3) Amber/Booth "BSRA"
        4) Aeroflex "RSH"
        5) Vibration Eliminator Co. "SNC".
        6) Vibro Acoustics "SH/SHC"

C. Type H3:

1. Vibration hangers shall have a steel spring in a neoprene cup with a grommet to prevent short circuiting of the hanger rod.
2. The cup shall have a steel washer to distribute load on the neoprene and prevent its extrusion.
3. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30° arc before contacting the grommet and short circuiting the spring.
4. Provide end connections for hanging ductwork or piping.
5. Hangers shall be capable of holding the load at a fixed elevation during installation. They shall have a secondary adjustment to transfer the load to the spring and maintain the same position.
6. Deflection shall be indicated by a pointer and scale.

    a. Manufacturer:

        1) Mason "30N"
        2) Kinetics "SFH"
        3) Amber/Booth "BSW"
        4) Vibration Eliminator Co. "SNRC"
        5) Vibro Acoustics "SHR"

2.4 BASES

A. Type B3:

1. Rectangular structural channel concrete forms for floating foundations.
2. Where applicable, bases shall be large enough to support suction elbows, discharge elbows, and suction diffusers.
3. Channel depth shall be at least 1/12 the longest dimension of the base but not less than 6" . Depth need not exceed 12" if rigidity is acceptable to equipment manufacturer.
4. Forms shall include 1/2" rebars welded on 6" centers running both ways in a layer 1-1/2" above the bottom, and drilled steel members with sleeves welded below the holes to receive the equipment anchor bolts.
5. Contractor shall pour 3,300 PSI concrete inside entire base. Concrete to be same thickness as sides of base. Trowel concrete smooth on top of base.
6. Use height saving brackets, unless noted otherwise.

a. Manufacturers:

1) Mason "K"
2) Kinetics "CIB-H"
3) Aeroflex "MPF"
4) Amber Booth "CPF"
5) Bulldog, Inc.
6) Vibration Eliminator Co. "SN".

2.5 FLEXIBLE CONNECTORS (NOISE AND VIBRATION ELIMINATORS)

A. Type FC2:

1. Stainless steel flexible connectors with corrugated stainless steel hose body and stainless steel braided casing.
2. Rated for minimum working pressures of 150 psi at 70°F and 100 psi at 800°F .
3. Sizes 2" and under shall have steel threaded connections.
4. Sizes 2-1/2" and over shall have 150 lb. steel flanges.
5. Suitable for 1/2" permanent misalignment.
6. Limitations: Not for use in domestic water systems.

a. Manufacturers:

1) Mason or Mercer "BSS-GU"
2) Metraflex "ML"
3) Twin City Hose "TCHS"
4) American "BOA B4-1"
5) Flexible Metal Hose Company "FM-21"
6) or Wheatley.

B. Type FC3:

1. Rated for minimum working pressures of 150 psi at 70°F and 100 psi at 800°F.
2. Sizes 2" and under shall be braided bronze hose with copper sweat ends or stainless steel braided hose with stainless steel threaded nipples,
3. Sizes 2-1/2" and over shall be stainless steel braided hose with 150 lb. stainless steel flanges.
4. Suitable for 1/2" permanent misalignment.
5. All components shall be lead free per Federal Act S.3874, Reduction of Lead in Drinking Water Act and NSF/ANSI-61 Low Lead Requirements for Drinking Water.

a. Manufacturers:

1) Mason or Mercer "CPSB-NSF", "NSS-NSF" or "FLSS-NSF"

2) Metraflex "BBSC", SSTT or "MMCC"
3) Twin City Hose "ULTCHB", "UL-TCHSSMMT" or "ULTCHSSFLG"
4) Flexible Metal Hose Company "BSW", "SSMN" or "SSMP"

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION

A. Install all products per manufacturer's recommendations.

B. Provide vibration isolation as indicated on the drawings and as described herein.

C. Clean the surface below all mountings that are not bolted down and apply adhesive cement equal to Mason Type WG between mounting and floor. If movement occurs, bolt mountings down. Isolate bolts from baseplates with neoprene washers and bushings.

D. All static deflections listed in the drawings and specifications are the minimum acceptable actual deflection of the isolator under the weight of the installed equipment - not the maximum rated deflection of the isolator.

E. Support equipment to be mounted on structural steel frames with isolators under the frames or under brackets welded to the frames. Where frames are not needed, fasten isolators directly to the equipment.

F. Where a specific quantity of hangers is noted in these specifications, it shall mean hanger pairs for support points that require multiple hangers, such as pipes supported on a strut rack.

3.2 PIPE ISOLATION

A. The first five hangers from vibration-isolated equipment shall have spring isolators with the same static deflection as the equipment. Use type H1 or H2 as required for the specified deflection. The next five hangers shall be type H1.

B. For base mounted pumps without resilient mountings, the first five hangers shall be Type H1.

C. Where piping is floor-supported, use M2 instead of H1 and M3 instead of H2.

D. Install flexible connectors in all piping connected to vibration producing equipment. This includes all base-mounted pumps, compressors, etc. Absence of flexible connectors on piping diagrams does not imply that they are not required.

E. Use Type FC1 where pressures are lower than 150 psi, temperatures are below 220°F, and the fluid handled is non-potable and compatible with neoprene and EPDM.

F. Use Type FC2 for all other non-potable services. FC2 shall be installed parallel with equipment shafts.

G. Use Type FC3 for all potable water services. FC3 shall be installed parallel with equipment shafts.

H. Provide sufficient piping flexibility for vibrating equipment or furnish flexible connectors with appropriate temperature and pressure ratings.

I. Vibration isolators shall not cause any change in position of piping that will result in stresses in connections or misalignment of shafts or bearings. Equipment and piping shall be maintained in a rigid position during installation. Do not transfer load to the isolators until the installation is complete and under full operational load. Hanger H3 and Mounting M4 may be used instead of other products for this purpose.

J. Support piping to prevent extension of flexible connectors.

3.3 VIBRATION ISOLATION SCHEDULE

A. Inline Pumps:

1. Base Type: NA
2. Isolator Type: M3 or H2 or H3
3. Static Deflection: 0.75"
4. Flexible Connections: NA

B. Base-Mounted Domestic Water Booster Pumps:

1. Base Type: B3
2. Isolator Type: M3
3. Static Deflection: 0.75"
4. Flexible Connections: FC-3

C. Air Compressor or Vacuum Pump:

1. Base Type: B3
2. Isolator Type: M3
3. Static Deflection: 0.75"
4. Flexible Connections: FC-2

END OF SECTION 22 05 48

VIBRATION ISOLATION SUBMITTAL FORM

COLUMN 1	2	3	4	5	6	7	8	9	10	11	12
		PROPOSED ISOLATOR							CALCULATIONS		
ITEM SERVED	MIN DEFL (")	TAG	MODEL	MAX LOAD (#)	DEFL @ MAX LOAD (")	DEFL TO SOLID (")	FREE HT (")	Kx/Ky	LOAD (#)	DEFL (")	DEFL RATIO

COLUMN NOTES: Note numbers correspond to the column numbers above.
1. Item served should match designation on the design drawings.
2. List the deflection scheduled or specified in the design documents.
3. List the designation for this isolator. This is most useful when one item has multiple different isolators to support its weight.
4. List the manufacturer's complete model designation for the isolator.
5. List the manufacturer's maximum rated load for the isolator.
6. List the isolator deflection at the maximum rated load in column 5.
7. For spring isolators list the deflection when the springs are solid. This is not normally the same entry as in column 6.
8. List the height of the isolator when unloaded. Shop drawings must show where this is measured.
9. List the rated horizontal to vertical stiffness ratio. This must be between 0.8 and 2.0.
10. List the calculated equipment load on each isolator. For items with unequal weight distribution, calculate each isolator separately.
11. List the calculated deflection under the calculated load. For springs this will be column 10*(column 6 / column 5).
12. List the answer from dividing column 7 by column 11. This must be at least 1.5. If not, select an isolator with more nominal deflection.

GENERAL NOTES:
1. When submitting hangers or supports for a weight range, fill in two rows - one for the maximum and one for the minimum weight.

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SECTION 22 05 50 - SEISMIC REQUIREMENTS FOR EQUIPMENT AND SUPPORTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Seismic Requirements.

1.2 QUALITY ASSURANCE

A. General:

1. The contractor shall retain a specialty consultant or equipment manufacturer to develop a seismic restraint and support system and perform seismic calculations in accordance with these specifications, state, and local codes.
2. Items used for seismic restraint of equipment and systems shall be specifically manufactured for seismic restraint.
3. These requirements are beyond those listed in Section 22 05 29 of these specifications. Where a conflict arises between the seismic requirements of this section and any other section, the Architect/Engineer shall be immediately notified for direction to proceed.

B. Manufacturer:

1. System Supports/Restraints: Company specializing in the manufacture of products specified in this Section.
2. Equipment: Each company providing equipment that must meet seismic requirements shall provide certification included in project submittals the equipment supplied for the project meets or exceeds the seismic requirements of the project.

C. Testing Agency: An independent testing agency, acceptable to Authorities Having Jurisdiction, with experience and capability to conduct the testing indicated.

D. Installer: Company specializing in performing the work of this Section.

1.3 SUBMITTALS

A. Submit under provisions of Section 22 05 00.

B. Shop Drawings:

1. Calculations, restraint selections, and installation details shall be designed and sealed by a Professional Engineer licensed in the state where the project is located experienced in seismic restraint design and installation.
2. Coordination Drawings: Plans and sections drawn to scale, coordinating seismic bracing of mechanical components with other systems and equipment in the vicinity, including other seismic restraints.
3. Manufacturer's Certifications: Professional Engineer licensed in the state where the project is located shall review and approve manufacturer's certifications of compliance.
4. System Supports/Restraints - Submit for each condition requiring seismic bracing:

   a. Calculations for each seismic brace and detail utilized on the project.
   b. Plan drawings showing locations and types of seismic braces on contractor fabrication/installation drawings.

c. Cross-reference between details and plan drawings to indicate exactly which brace is being installed at each location. Details provided are to clearly indicate attachments to structure, correctly representing the fastening requirements of bracing.

d. Clear indication of brace design forces and maximum potential component forces at attachment points to building structure for confirmation of acceptability by the Structural Engineer of Record.

5. Equipment - Submit for each piece of equipment supplied:

a. Certification that the equipment supplied for the project meets or exceeds the seismic requirements specified.

b. Specific details of seismic design features of equipment and maximum seismic loads imparted to the structural support.

c. Engineering calculations and details for equipment anchorage and support structure.

C. A seismic restraint designer shall be provided whether or not exceptions listed in the applicable building code are met. If seismic restraints are not provided for a system that requires seismic bracing, the seismic designer shall submit a signed and sealed letter to the Architect/Engineer and Authorities Having Jurisdiction stating the exceptions, along with code reference, utilized for each item. Seismic designer shall review system installation for general conformance to the exception requirements stated in the code and document, in writing, the system has been installed in accordance to the exception.

1.4 TESTING AND INSPECTION

A. Special Inspection and Testing shall be done in accordance with Chapter 17 of the Building Code.

B. The Owner shall employ a Special Inspection Agency to perform the duties and responsibilities specified in Section 1704 and 1705.

C. Work performed on the premises of a fabricator approved by the building official need not be tested and inspected. The fabricator shall submit a certificate of compliance that the work has been performed in accordance with the approved plans and specifications to the building official and the Architect and Engineer of Record.

D. The Special Inspection Agency shall furnish inspection reports to the building official, the Owner, the Architect, the Engineer of Record, and the General Contractor. The reports shall be completed and furnished within 48 hours of inspected work. A final signed report stating whether the work requiring special inspection was, to the best of the Special Inspection Agency's knowledge, in conformance with the approved plans and specifications shall be submitted.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site. Accept material on site in factory containers and packing. Inspect for damage. Protect from damage and contamination by maintaining factory packaging until installation. Follow manufacturer's instructions for storage.

1.6 DESIGN REQUIREMENTS

A. This project is subject to the seismic bracing requirements of the International Building Code, 2012 edition.

B. The following criteria are applicable to this project:

1. Risk Category: II
2. Seismic Importance Factor: IE = 1.0Seismic Design Category: C

3. Component Amplification Factors (ap) and Component Response Modification Factors (Rp) shall be taken from Table 13.5-1 in ASCE 7-10 for the individual equipment or system being restrained.
4. Component Importance Factors (Ip) shall be taken from Section 13.1.3 in ASCE 7-10 for the individual equipment or system being restrained.
5. The total height of the structure and the height of the system to be restrained within the structure shall be determined in coordination with architectural plans and the General Contractor.

C. Forces shall be calculated with the above requirements and Equations 13.3-1, -2, and -3 of ASCE 7-10, unless exempted by 13.1.4.

D. Equipment shall meet International Building Code and ASCE 7 seismic qualification requirements in concurrence with ICC ES AC156 Acceptance Criteria for Seismic Qualification by Shake-Table Testing of Nonstructural Components and Systems.

E. All seismic anchorage and bracing shall comply with FM Global Property Loss Prevention Data Sheet 1-11, Fire Following Earthquakes.

1.7 COORDINATION

A. Coordinate layout and installation of seismic bracing with building structural systems and architectural features, and with mechanical, fire-protection, electrical and other building features in the vicinity.

B. Coordinate concrete bases with building structural system.

1.8 WARRANTY

A. Provide one-year warranty on parts and labor for manufacturer defects and installation workmanship.

PART 2 - PRODUCTS

2.1 SUPPLIERS

A. Following is a partial list of manufacturer/supplier contact information for seismic restraints:

1. B-Line Systems, Inc. (800) 851-7415, www.b-line.com.
2. Unistrut Corporation http://www.unistrut.us/
3. Kinetics Noise Control (877) 457-2695, www.kineticsnoise.com.
4. Mason Industries, Inc. www.mason-ind.com.
5. Loos & Co., Inc. (800) 321-5667, www.loosnaples.com.
6. Tolco (909) 737-5599, www.tolco.com
7. ISAT 877.523.6060, www.isatsb.com
8. Vibro-Acoustics (416) 291-7371, https://virs.vibro-acoustics.com/

2.2 SEISMIC DESIGN CRITERIA

A. This section describes the requirements for seismic restraint of systems and equipment related to continued operation of the facility after a design seismic event.

B. Definitions

1. Stay in Place:

a. All systems and equipment shall be anchored and restrained such that the anchoring system is intended not to fail and equipment and/or system components will not fall.

2. Remain Operational:

   a. Requirements for "Stay in Place" listed above shall be met.
   b. The following systems and associated equipment are intended not to fail externally or internally and are intended to remain operational.

      1) Fire Protection
      2) Heating
      3) Cooling
      4) Exhaust

2.3 SEISMIC BRACING AND SUPPORT OF SYSTEMS AND COMPONENTS

A. General:

1. Seismic restraint designer shall coordinate all attachments with the Structural Engineer of Record; refer to submittal requirements.
2. The seismic restraint design shall be based on actual equipment data obtained from manufacturer's submittals or the manufacturer. The equipment manufacturer shall verify and provide written certification the attachment points on the equipment can accept the combination of seismic, weight, and other imposed loads.
3. Design analysis shall include calculated dead loads, static seismic loads, and capacity of materials utilized for the connection of the equipment or system to the structure.
4. Analysis shall detail anchoring methods, bolt diameter, embedment, and weld length.
5. All seismic restraint devices shall be designed to accept without failure the forces calculated per the applicable building code.
6. All seismic restraints and combination isolator/restraints shall have verification of their seismic capabilities witnessed by an independent testing agency.

B. Friction from gravity loads shall not be considered resistance to seismic forces.

C. Fire protection systems shall meet the requirements of NFPA-13 and NFPA-14 for the building seismic requirements.

D. Housekeeping Pads:

1. Reinforced housekeeping pads shall be provided to handle shear, tension, and compression forces with proper reinforcement, doweling, and attachments connecting the pad to the structural slab.

2.4 SEISMIC RESTRAINT AND CONSTRUCTION OF EQUIPMENT

A. Equipment supplied for the project shall be designed to meet the requirements of lateral forces calculated using the applicable code and method described above.

B. The following is a partial list of equipment that shall be restrained and that shall be constructed to meet seismic forces described in this section:

1. Air Compressors
2. Pumps
3. Tanks
4. Fire Protection Equipment
5. Fire Pumps

2.5 MATERIALS

A. Use the following materials for restraints:

1. Indoor Dry Locations: Steel, zinc plated.
2. Outdoors and Damp Locations: Galvanized steel.
3. Corrosive Locations: Stainless steel.

2.6 ANCHORAGE AND STRUCTURAL ATTACHMENT COMPONENTS

A. Strength: Defined in reports by ICC Evaluation Service or another agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Strength in tension and shear of components used shall be at least two times the maximum seismic forces to which they will be subjected.

B. Concrete and Masonry Anchor Bolts and Studs: Steel-expansion wedge type. Comply with IBC, ACI and ICC ES requirements for cracked concrete anchors.

C. Concrete Inserts: Steel-channel type.

D. Through Bolts: Structural type, hex head, high strength. Comply with ASTM F3125, Grade A 325.

E. Welding Lugs: Comply with MSS SP-69, Type 57.

F. Beam Clamps for Steel Beams and Joists: Double sided. Single-sided type is not acceptable.

G. Bushings for Floor-Mounted Equipment Anchors: Neoprene units designed for seismically rated rigid equipment mountings, and matched to the type and size of anchor bolts and studs used.

H. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for seismically rated rigid equipment mountings, and matched to the type and size of attachment devices used.

2.7 SEISMIC BRACING COMPONENTS

A. Slotted Steel Channel: 1-5/8-by-1-5/8-inch cross section, formed from 0.1046-inch-thick steel, with 9/16-by-7/8-inch slots at a maximum of 2 inches o.c in webs, and flange edges turned toward web.

1. Materials for Channel: ASTM A 1011, GR 33.
2. Materials for Fittings and Accessories: ASTM A 635, ASTM A 576, or ASTM A 36.
3. Fittings and Accessories: Products of the same manufacturer as channels and designed for use with that product.
4. Finish: Baked, rust-inhibiting, acrylic-enamel paint applied after cleaning and phosphate treatment, unless otherwise indicated.

B. Channel-Type Bracing Assemblies: Slotted steel channel, with adjustable hinged steel brackets and bolts.

C. Cable-Type Bracing Assemblies: Zinc-coated, high-strength steel wire rope cable attached to steel thimbles, brackets, and bolts designed for cable service.

1. Arrange units for attachment to the braced component at one end and to the structure at the other end.
2. Wire Rope Cable: Comply with ASTM A 603. Use 49- or 133-strand cable with a minimum strength of 2 times the calculated maximum seismic force to be resisted.

D. Hanger Rod Stiffeners: Slotted steel channels with internally bolted connections to hanger rod.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer to the applicable code sections and Authority Having Jurisdiction for the exact seismic restraint requirements of piping, ductwork, conduit, equipment, etc.

B. Layout of transverse and longitudinal bracing shall follow recommendations of approved design standards listed in Part 1 of this specification section.

C. All rigid floor mounted equipment shall have a resilient media between the equipment mounting hole and the anchor bolt in concrete.

D. All seismic restraint systems shall be installed in strict accordance with the manufacturer's written instructions and all certified submittal data.

E. Installation of seismic restraints shall not cause any change in position of equipment, piping, or ductwork, resulting in stresses or misalignment.

F. No rigid connections between equipment and the building structure shall be made that degrade the noise and vibration-isolation system specified.

G. Do not install any equipment, piping, duct, or conduit that makes rigid connections with the building unless isolation is not specified.

H. Coordinate work with all other trades to avoid rigid contact with the building. Any conflicts with other trades that will result in rigid contact with equipment or piping due to inadequate space or other unforeseen conditions shall be brought to the Architect/Engineer's attention prior to specific equipment selection.

I. Prior to installation, bring to the Architect/Engineer's attention any discrepancies between the specifications and the field conditions, or changes required due to specific equipment selection.

J. Bracing may occur from flanges of structural beams, upper truss cords of bar joists, cast in place inserts, or International Code Council approved seismic anchors for installation in concrete.

K. Cable restraints shall be installed slightly slack to avoid short-circuiting the isolated suspended equipment, ductwork, piping, or conduit.

L. Cable assemblies shall be installed taut on non-isolated systems. Solid braces may be used in place of cables on rigidly attached systems only.

M. Do not install cables over sharp corners.

N. Brace support rods when necessary to accept compressive loads. Welding of compression braces to the vertical support rods is not acceptable.

O. Provide reinforced clevis bolts when required.

P. The vibration isolation manufacturer shall furnish integral structural steel bases as required. Independent steel rails are not acceptable.

Q. Post-Installed anchors shall be provided to meet seismic requirements.

R. Vertical pipe risers flexibly supported to accommodate thermal motion and/or pipe vibration shall be guided to maintain pipe stability and provide horizontal seismic restraint.

S. Seismic restraints shall be mechanically attached to the system. Looping restraints around the system is not acceptable.

T. Piping crossing building seismic or expansion joints, passing from building to building, or supported from different portions of the building shall be installed to allow differential support displacements without damaging the pipe, equipment connections, or support connections. Pipe offsets, loops, anchors, and guides shall be installed as required to provide required motion capability and limit motion of adjacent piping.

U. Water tanks shall be secured to their saddles by welding or proper concrete attachment, and those saddles shall be properly attached to the structure.

V. Brace all terminal units with water coils as required by the building code and provide flexible connection to the coil if bracing is required.

W. Independently brace duct mounted equipment (terminal units, in-line fans, etc.) and the associated suspended ductwork.

X. Do not brace a system to two different structures such as a wall and a ceiling.

Y. Provide appropriately sized openings in walls, floors, and ceilings for anticipated seismic movement. Provide fire seal systems in fire-rated walls.

Z. Positively attach all roof mounted equipment to roof curbs. Positively attach all roof curbs to building structure.

AA. Exposed seismic supports in occupied areas shall be guarded or covered to protect occupants.

BB. Coordinate seismic bracing of architecturally exposed ductwork with the Architect/Engineer.

3.2 SEISMIC RESTRAINT EXCLUSIONS

A. Refer to the applicable code sections and Authority Having Jurisdiction for allowable exclusions.

END OF SECTION 22 05 50

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SECTION 22 05 53 - PLUMBING IDENTIFICATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Identification of products installed under Division 22.

1.2 SUBMITTALS

A. Submit shop drawings under provisions of Section 22 05 00. Include list of items identified, wording, letter sizes, and color coding.

B. Include valve chart and schedule listing valve tag number, location, function, and valve manufacturer's name and model number.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

1. 3M
2. Bunting
3. Calpico
4. Craftmark
5. Emedco
6. Kolbi Industries
7. Seton
8. W.H. Brady
9. Marking Services

2.2 MATERIALS

A. All pipe markers (purchased or stenciled) shall conform to ANSI A13.1. Marker lengths and letter sizes shall be at least the following:

OD of Pipe or Insulation	Marker Length	Size of Letters
Up to and including 1-1/4"	8"	1/2"
1-1/2" to 2"	8"	3/4"
2-1/2" to 6"	12"	1-1/4"
8" to 10"	24"	2-1/2"
Over 10"	32"	3-1/2"

Plastic tags may be used for outside diameters under 3/4"

B. Plastic Tags: Minimum 1-1/2" square or round laminated three-layer phenolic with engraved, 1/4" minimum black letters on light contrasting background.

C. Equipment tags shall be metal plates etched with equipment information and attached to equipment. Etched information shall include the following.

D. Brass Tags: Brass background with engraved black letters. Tag size minimum 1-1/2" square or 1-1/2" round.

E. Plastic Pipe Markers: Semi-rigid plastic, preformed to fit around pipe or pipe covering; indicating flow direction and fluid conveyed.

F. Vinyl Pipe Markers: Colored vinyl with permanent pressure sensitive adhesive backing.

G. Stencil Painted Pipe Markers: Use industrial enamel spray paint per ANSI Standard A13.1. Indicate fluid conveyed and flow direction.

H. Underground Pipe Markers: Bright colored continuously printed plastic ribbon tape 6" wide by 3.5 mils thick, manufactured for direct burial, with aluminum foil core for location by non-ferric metal detectors and bold lettering identifying buried item.

I. Tracer Wire:

1. Single copper conductors shall be solid or stranded annealed or hard uncoated copper per UL83 and ASTM requirements. Tracer tape or copper-coated steel wire is not acceptable.
2. Conductor shall be insulated with HMWPE as specified and applied in a concentric manner. The minimum at any point shall not be less than 90% of the specified average thickness in compliance with UL 83.
3. Tracer wire shall be continuously spark tested at 7500 Volts DC. Other electrical and mechanical tests shall be in accordance with UL 1581.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all products per manufacturer's recommendations.

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

C. Valves:

1. All valves (except shutoff valves at equipment) shall have numbered tags.
2. Provide or replace numbered tags on all existing valves that are connected to new systems or that have been revised.
3. Provide all existing valves used to extend utilities to this project with numbered tags. Review tag numbering sequence with the Owner prior to ordering tags.
4. Secure tags with heavy duty key chain and brass "S" link or with mechanically fastened plastic straps.
5. Attach to handwheel or around valve stem. On lever operated valves, drill the lever to attach tags.
6. Number all tags and show the service of the pipe.
7. Provide one Plexiglas framed valve directory listing all valves, with respective tag numbers, uses and locations. Mount directory in location chosen by the Architect/Engineer.

D. Pipe Markers:

1. Adhesive Backed Markers: Use Brady Style 1, 2, or 3 on pipes 3" diameter and larger. Use Brady Style 4, 6, or 8 on pipes under 3" diameter. Similar styles by other listed manufacturers are acceptable. Secure all markers at both ends with a wrap of pressure sensitive tape completely around the pipe.
2. Snap-on Markers: Use Seton "Setmark" on pipes up to 5-7/8" OD. Use Seton "Setmark" with nylon or Velcro ties for pipes 6" OD and over. Similar styles by other listed manufacturers are acceptable.
3. Stencil Painted Pipe Markers:

a. Remove rust, grease, dirt, and all foreign substances from the pipe surface.
b. Apply primer on non-insulated pipes before painting.
c. Use background and letter colors as scheduled later in this section.

4. Apply markers and arrows in the following locations where clearly visible:

a. At each valve.
b. On both sides of walls that pipes penetrate.
c. At least every 20 feet along all pipes.
d. On each riser and each leg of each "T" joint.
e. At least once in every room and each story traversed.

5. Underground Pipe Markers: Install 8" to 10" below grade, directly above buried pipes.

E. Equipment:

1. All equipment not easily identifiable such as controls, relays, gauges, etc.; and all equipment in an area remote from its function shall have nameplates or plastic tags listing name, function, and drawing symbol. Do not label exposed equipment in public areas.
2. Provide engraved plastic tags at all hydronic or steam system makeup water meters.
3. Mechanical equipment that is not covered by the U.S. National Appliance Energy Conservation Act (NAECA) of 1987 shall carry a permanent label installed by the manufacturer stating that the equipment complies with the requirements of ASHRAE 90.1.

F. Tracer Wire:

1. Tracer wire shall be installed on top of all non-metallic buried utilities.
2. Tracer wire shall be taped directly to plastic water or drain pipe.
3. Tracer wire shall not be fastened directly or indirectly to gas piping.
4. Tracer wire when attached shall be secured to the pipe a minimum of every 10 feet and at all changes of direction.
5. Tape shall be Polyken "930-35", Protecto-Wrap "310", or approved equal.
6. Tracer wire shall be continuous between boxes and shall be tested for continuity.
7. Splices in tracer wire shall be made with a waterproof splice kit to prevent corrosion. Wire nuts shall not be used.
8. The tracer wire shall daylight to grade through a 2" PVC conduit, at the point of the utility entrance to building. PVC conduit shall be capped and labeled as future contact point to locate the utility.

3.2 SCHEDULE

A. Pipes to be marked shall be labeled with text as follows, regardless of which method or material is used:

1. CONDENSATE DRAIN: White lettering; green background
2. COMPRESSED AIR: White lettering; green background
3. DOMESTIC COLD WATER: White lettering; green background
4. DOMESTIC HOT WATER - 115°F: White lettering; green background
5. DOMESTIC HOT WATER - 140°F: White lettering; green background
6. SANITARY SEWER: Black lettering; yellow background
7. VENT: Black lettering; yellow background
8. STORM SEWER (PRIMARY AND SECONDARY): White lettering; green background
9. NATURAL GAS: Black lettering; yellow background
10. TEMPERED WATER: White lettering; green background
11. TEMPERED WATER RETURN: White lettering; green background
12. INSTRUMENT AIR - 160-185 PSI: White lettering; black background
13. All Underground Pipes: Varies
14. Tracer Wire - Natural Gas Pipelines: Black lettering; yellow background
15. Tracer Wire - All other buried types: White lettering; green background

B. Non-Potable Piping: All piping conveying non-potable water shall be permanently identified by continuously painted or continuous adhesive backed marker along entire length of pipe and branches so the piping is readily distinguishable from piping carrying potable water. Pipe markers shall be located as described above.

1. NON-POTABLE WATER: White lettering; purple background
2. IRRIGATION WATER: White lettering; purple background
3. DEIONIZED WATER: White lettering; purple background
4. DISTILLED WATER: White lettering; purple background
5. RO WATER: White lettering; purple background

END OF SECTION 22 05 53

SECTION 22 07 19 - PLUMBING PIPING INSULATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Piping Insulation.

B. Insulation Jackets.

1.2 QUALITY ASSURANCE

A. Applicator: Company specializing in piping insulation application with five years minimum experience.

B. Materials: Listed and labeled for flame spread/smoke developed rating of no more than 25/50 when tested per ASTM E84 or UL 723 as required by code. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers with appropriate markings of applicable testing agency.

C. Products shall not contain asbestos, lead, mercury, or mercury compounds.

D. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

PART 2 - PRODUCTS

2.1 INSULATION

A. Type A: Glass fiber; ANSI/ASTM C547; 0.24 maximum 'K' value at 75°F; non-combustible. All-purpose polymer or polypropylene service jacket, listed and labeled at no more than 25/50 when tested per ASTM E84 or UL 723 as required by code.

B. Type B: Flexible elastomeric foam insulation; closed-cell, sponge or expanded rubber (polyethylene type is not permitted); ANSI/ASTM C534 Grade 1 Type I for tubular materials; flexible plastic; 0.25 maximum 'K' value at 75°F, listed and labeled at no more than 25/50 when tested per ASTM E84 or UL 723 as required by code. Maximum 1" thick per layer where multiple layers are specified.

2.2 VAPOR BARRIER JACKETS

A. All-purpose polymer or polypropylene service jacket vapor barrier with self-sealing adhesive joints. Beach puncture resistance ratio of at least 50 units. Tensile strength: 35 psi minimum. Single, self-seal acrylic adhesive on longitudinal jacket laps and butt strips.

B. Polyvinylidene Chloride (PVDC or Saran) film and tape: Durable and highly moisture and moisture vapor resistant. Please refer to manufacturer's recommended installation guidelines.

2.3 JACKET COVERINGS

A. Aluminum Jackets: ASTM C1729; 0.016" thick (thicker where required by ASTM C1729); stucco embossed finish with Z edge seams and aluminum bands for outdoor use. Where colored jacket covers are called for, provide factory-applied hard film acrylic paint in color selected by Architect.

B. Stainless Steel Jackets: ASTM C1767. Type 304 stainless steel; 0.010" thick (thicker where required by ASTM C1729); smooth finish with Z edge seams and stainless steel bands for outdoor use.

C. Plastic Jackets and Fitting Covers: High impact, glossy white, 0.020" thick, self-extinguishing plastic. Suitable for use indoors or outdoors with ultraviolet inhibitors. Suitable for -40°F to 150°F. Listed and labeled at no more than 25/50 when tested per ASTM E84 or UL 723 as required by code.

PART 3 - EXECUTION

3.1 PREPARATION

A. Install insulation after piping has been tested. Pipe shall be clean, dry and free of rust before applying insulation.

3.2 INSTALLATION

A. General Installation Requirements:

1. Install materials per manufacturer's instructions, building codes and industry standards.
2. Continue insulation with vapor barrier through penetrations. This applies to all insulated piping. Maintain fire rating of all penetrations.

B. Insulated Piping Operating Below 60°F:

1. Insulate fittings, valves, unions, flanges, strainers, flexible connections, flexible hoses, and expansion joints. Seal all penetrations of vapor barrier.
2. On piping operating below 60°F in locations that are not mechanically cooled (e.g., penthouses, mechanical rooms, tunnels, chases at exterior walls, etc.), Type B insulation shall be used.
3. All balance valves with fluid operating below 60°F shall be insulated with a removable plug wrapped with vapor barrier tape to allow reading and adjusting of the valve.

C. Insulated Piping Operating Between 60°F and 140°F:

1. Do not insulate flanges and unions, but bevel and seal ends of insulation at such locations. Insulate all fittings, valves and strainers.

D. Insulated Piping Operating Above 140°F:

1. Insulate fittings, valves, flanges, and strainers.
2. All balance valves with fluid operating above 140°F shall be insulated and an opening shall be left in the insulation to allow for reading and adjusting the valve.

E. Exposed Piping:

1. Locate and cover seams in least visible locations.
2. Where exposed insulated piping extends above the floor, provide a sheet metal guard around the insulation extending 12" above the floor. Guard shall be 0.016" cylindrical smooth or stucco aluminum and shall fit tightly to the insulation.

3. On exposed piping serving kitchen equipment or plumbing fixtures, the piping shall be insulated unless local code allows it to be uninsulated. In no instance should the uninsulated portion of the piping be more than 4ft in developed length.

3.3 SUPPORT PROTECTION

A. Provide a shield on all insulated piping at each support between the insulation jacket and the support.

B. On all insulated piping greater than 1-1/2", provide shield with insulation insert of same thickness and contour as adjoining insulation at each support, between the pipe and insulation jacket, to prevent insulation from sagging and crushing. Inserts shall be as follows:

1. The insert shall be suitable for planned temperatures, be suitable for use with specific pipe material, and shall be a minimum 180° cylindrical segment the same length as metal shields. Inserts shall be:

a. Molded hydrous calcium silicate (only use for pipes with operating temperatures above 90°F, with a minimum compressive strength of 100 psi is acceptable for pipe sizes 14" and below. For pipe sizes larger than 14", provide rolled steel plate in addition to the shield.
b. Polyisocyanurate insulation (for pipes below 300°F with a minimum compressive strength of 24 psi is acceptable for pipe sizes 3" and below, minimum 60 psi for pipe sizes 4" to 10". For pipe sizes larger than 10", provide rolled steel plate in addition to the shield Where insulation is installed on piping located within return air plenums and mechanical rooms, insulation shall be listed and labeled at no more than 25/50 when tested per ASTM E84 or UL 723 as required by code.
c. Cellular glass (for all temperature ranges) with a minimum compressive strength of 90 psi is acceptable for pipe sizes 14" and below. For pipe sizes larger than 14", provide rolled steel plate in addition to the shield.
d. Phenolic (for pipes operating below 250°F with a minimum compressive strength of 90 psi is acceptable for pipe sizes 14" and below. For pipe sizes larger than 14", provide rolled steel plate in addition to the shield.
e. As an alternative to separate pipe insulation insert and saddle, properly sized manufactured integral rigid insulation insert and shield assemblies may be used.

1) Products:

a) Buckaroo CoolDry
b) Cooper/B-Line Fig. B3380 through B3384
c) Pipe Shields A1000, A2000

f. Insulation Couplings:

1) Molded thermoplastic slip coupling, -65°F to 275°F, sizes up to 4-1/8" OD, and receive insulation thickness up to 1". Suitable for use indoors or outdoors with UV stabilizers. Vertical insulation riser clamps shall have a 1,000lb vertical load rating. On cold pipes operating below 60°F, cover joint and coupling with vapor barrier mastic to ensure continuous vapor barrier.
2) Horizontal Strut Mounted Insulated Pipe Manufacturers:

a) Klo-Shure or equal

3) Vertical:

a) Manufacturers: Klo-Shure Titan or equal

g. Rectangular blocks, plugs, or wood material are not acceptable.
h. Temporary wood blocking may be used by the Piping Contractor for proper height; however, these must be removed and replaced with proper inserts by the Insulation Contractor. Refer to Supports and Anchors specification section for additional information.

C. Neatly finish insulation at supports, protrusions, and interruptions.

D. Install metal shields between all hangers or supports and the pipe insulation. Shields shall be galvanized sheet metal, half-round with flared edges. Adhere shields to insulation. On cold piping, seal the shields vapor-tight to the insulation as required to maintain the vapor barrier, or add separate vapor barrier jacket.

E. Shields shall be at least the following lengths and gauges:

Pipe Size	Shield Size
1/2" to 3-1/2"	12" long x 18 gauge
4"	12" long x 16 gauge
5” to 6"	18" long x 16 gauge
8” to 14"	24" long x 14 gauge
16” to 24"	24" long x 12 gauge

F. Ferrous hot piping 4 inches and larger, provide steel saddle at rollers as described in Section 22 05 29 "Plumbing Supports and Anchors".

G. Minimum 1/4" rolled galvanized steel plates shall be provided in addition to the sleeves as reinforcement on large pipes to reduce point loading on roller, trapeze hanger and strut support locations depending on insulation compressive strength. Refer to section above for exact locations.

3.4 INSULATION

A. Type A Insulation:

1. All Service Jackets: Seal all longitudinal joints with self-seal laps using a single pressure sensitive adhesive system. Do not staple.
2. Insulation without self-seal lap may be used if installed with Benjamin Foster 85-20 or equivalent Chicago Mastic, 3M or Childers lap adhesive.
3. Apply insulation with laps on top of pipe.
4. Fittings, Valve Bodies and Flanges: For 4" and smaller pipes, insulate with 1 lb. density insulation wrapped under compression to a thickness equal to the adjacent pipe insulation. For pipes over 4", use mitered segments of pipe insulation. Finish with preformed plastic fitting covers. Secure fitting covers with pressure sensitive tape at each end. Overlap tape at least 2" on itself. For pipes operating below 60°F seal fitting covers with vapor retarder mastic in addition to tape.

B. Type B Insulation:

1. Install per manufacturer's instructions or ASTM C1710.
2. Elastomeric Cellular Foam: Where possible, slip insulation over the open end of pipe without slitting. Seal all butt ends, longitudinal seams, and fittings with adhesive. At elbows and tees, use mitered connections. Do not compress or crush insulation at cemented joints. Joints shall be sealed completely and not pucker or wrinkle. Paint the outside of outdoor insulation with two coats of latex enamel paint recommended by the manufacturer.
3. Insulation Installation on Straight Pipes and Tubes:

   a. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
   b. Insulation must be installed in compression to allow for expansion and contraction. Insulation shall be pushed onto the pipe, never pulled. Stretching of insulation may result in open seams and joints.

4. Insulation Installation on Valves and Pipe Specialties:

   a. Install preformed sections of same material as straight segments of pipe insulation when available.

b. When preformed sections are not available, install mitered sections of pipe insulation to valve body.
c. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.

3.5 JACKET COVER INSTALLATION

A. Metal Covering:

1. Provide vapor barrier as specified for insulation type. Cover with aluminum stainless steel jacket covering with seams located on the bottom of horizontal piping. Include fittings, joints and valves.
2. Seal all interior and exterior butt joints with metal draw bands and sealant. Seal all exterior joints watertight.
3. Interior joints do not need to be sealed.
4. Use metal covering on the following pipes:

    a. All exterior piping.
    b. Cover insulation with aluminum jacketing.
    c. .

5. Use colored aluminum jacket covers on the following pipes:

    a. All exterior piping.
    b.

B. Plastic Covering:

1. Provide vapor barrier as specified for insulation type. Cover with plastic jacket covering. Position seams to shed water.
2. Solvent weld all joints with manufacturer recommended cement.
3. Overlap all laps and butt joints 1-1/2" minimum. Repair any loose ends that do not seal securely. Solvent weld all fitting covers in the same manner. Final installation shall be watertight.
4. Use plastic insulation covering on all exposed pipes including, but not limited to:

    a. All exposed piping in areas noted on drawings.
    b. All exposed piping below 8'-0" above floor.
    c. All piping in mechanical rooms and/or tunnels that is subject to damage from normal operations. (Example: Piping that must be stepped over routinely.)
    d. All kitchen areas.

5. Elastomeric piping insulation may have two coats of latex paint instead of plastic jacket.

3.6 SCHEDULE

A. Refer to drawings for insulation schedule.

END OF SECTION 22 07 19

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SECTION 22 08 01 - COMMISSIONING OF PLUMBING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Description

B. Responsibilities

C. Related Work

D. Test Equipment

1.2 DESCRIPTION

A. The purpose of this section is to specify Division 22 responsibilities in the commissioning process.

B. The systems to be commissioned are the project service water heating systems in IECC 2015 Section C408 applicable to the project.

1. Domestic Water Heater
2. Domestic Hot Water Recirculation Pump
3. Domestic Booster Pump
4. Water Softener
5. Pure Water System

1.3 RESPONSIBILITIES

A. Commissioning requires the participation of the Division 22 Contractor to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Section 01 91 01. Division 22 Contractor shall be familiar with all parts of Section 01 91 01 and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

B. Refer to Section 01 91 01 for more information.

1.4 RELATED WORK

A. Specific commissioning requirements are given in the following sections of these specifications. All the following sections apply to the Work of this section.

1. Section 01 78 23 - Operations and Maintenance
2. Section 01 79 00 - Demonstration and Training
3. Section 01 91 01 - Commissioning
4. Section 23 08 01 - Commissioning of HVAC
5. Section 26 08 01 - Commissioning of Electrical

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. The Contractor shall provide all test equipment necessary to fulfill the testing requirements of this Division. This equipment includes, but is not limited to, the following:

1. Handheld temperature and relative humidity meter.
2. Handheld infrared thermometer.
3. Analog differential pressure gauge and associated tubing.
4. Portable computer with access to the building automation system. This computer will be used by the Controls Contractor to demonstrate the operation of the systems tied to the BAS.

B. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the related specifications. If not otherwise noted, the following minimum requirements apply:

1. Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of +/- 0.1°F.
2. Pressure sensors shall have an accuracy of +/- 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.
3. All equipment shall be calibrated according to the manufacturer's recommended intervals and when dropped or damaged. Calibration tags shall be affixed or certificates readily available.

C. Refer to Section 01 91 01 for additional Division 22 requirements.

PART 3 - EXECUTION

A. Refer to Section 01 91 01 for more information.

END OF SECTION 22 08 01

SECTION 22 09 00 - INSTRUMENTATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Positive Displacement Meters.

B. Pressure Gauge.

C. Pressure Gauge Accessories.

D. Thermometers.

E. Test Plugs.

1.2 SUBMITTALS

A. Submit shop drawings per Section 22 05 00. Include list that indicates use, operating range, total range and location for manufactured components.

PART 2 - PRODUCTS

2.1 PRESSURE GAUGES

A. Gauges shall be 4-1/2” diameter with aluminum or stainless steel case with phosphor bronze bourdon tube, brass socket for water or oil application, 1/4" or 1/2" bottom connection. Gauges shall be 1% full scale accurate with bronze bushed brass movement and adjustable pointer. Standard ranges to be either pressure or pressure and vacuum as required of application.

1. Manufacturers:

a. Ashcroft
b. Marsh
c. Marshalltown
d. Miljoco
e. Trerice
f. U.S. Gauge Figure 1901
g. Weiss
h. Weksler
i. Wika.

B. Select gauge range for normal reading near center of gauge.

2.2 PRESSURE GAUGE ACCESSORIES

A. All pressure gauges shall have valves and pressure snubbers. All pressure gauges on steam shall have pigtail syphon.

B. Shutoff Valve: 1/4” ball valve as specified for each piping system.

C. Pressure snubber, brass with 1/4” connections, porous metal type.

2.3 THERMOMETERS

A. Dial Type:

1. 4-1/2” diameter, hermetically sealed case. Stainless steel case and stem. Accuracy of 1% full scale with external recalibrator.
2. Select thermometers for appropriate temperature range. Adjustable elbow joint with locking device to allow rotation of thermometer to any angle.
3. Stem lengths as required for application with minimum insertion of 2-1/2”.
4. Thermometers for water shall have brass or steel separable socket. Thermometer wells shall be stainless steel, pressure rated to match piping system design pressure; with 2-inch extension for insulated piping and threaded cap nut with chain permanently fastened to well and cap.
5. Manufacturer:

   a. Ashcroft
   b. Marsh
   c. Marshalltown
   d. Miljoco
   e. Tel-Tru
   f. Trerice
   g. U.S. Gauge
   h. Weiss
   i. Weksler
   j. Wika.

B. Alcohol/Spirit Filled Type:

1. 9” long phenolic case, steel stem, accuracy of 1% full scale. Adjustable elbow joint with 180 degree adjustment in vertical plane, 360 degree adjustment in horizontal plane, and locking device to allow rotation of thermometer to any angle.
2. Select thermometer for appropriate temperature range.
3. Stem: Copper plated steel, aluminum, or brass for separable socket. Stem lengths as required for application with minimum insertion of 3-1/2”.
4. Thermometers for water shall have brass or steel separable socket. Thermometer wells shall be stainless steel, pressure rated to match piping system design pressure; with 2-inch extension for insulated piping and threaded cap nut with chain permanently fastened to well and cap.
5. Manufacturer:

   a. Marsh
   b. Miljoco
   c. Trerice
   d. Weiss
   e. Weksler
   f. Wika.

C. Digital Type:

1. 1/2” LCD digital display, solar powered, with high impact ABS case. Accuracy of 1% of reading or 1°F, whichever is greater. Adjustable elbow joint with locking device to allow rotation of thermometer to any angle.
2. Fahrenheit/Celsius switchable with -50/300°F or -45/150°C range.
3. Through-case potentiometer recalibration adjustment.
4. Stem lengths as required for application, with minimum insertion of 2-1/2”.
5. Thermometers for water shall have brass or steel separable socket. Thermometer wells shall be stainless steel, pressure rated to match piping system design pressure; with 2-inch extension for insulated piping and threaded cap nut with chain permanently fastened to well and cap.

6. Digital display shall operate at 10 Lux (one foot-candle) or more. Use this thermometer only where ambient temperatures are below 140°F and there is sufficient light under normal occupied space conditions for the digital display to function. Use a different type thermometer where there is inadequate light available (e.g., dark mechanical rooms, locations where the thermometer is shielded from light, etc.).
7. Manufacturer:

   a. Miljoco
   b. Trerice
   c. Weiss
   d. Weksler
   e. Wika.

D. Dial Type with Remote Reading Dial:

1. 4-1/2” diameter remote mounted, vapor actuated dial, hermetically sealed case. Stainless steel case and stem. Accuracy of 1% full scale with external recalibrator.
2. Select thermometers for appropriate temperature range.
3. 0.13” diameter copper averaging bulb approximately 60" (long. Install dial as shown on drawings and in location visible from floor. Insulate copper averaging bulb if required by manufacturer.
4. Stem lengths as required for application with minimum insertion of 2-1/2”.
5. Thermometers for water, steam, or oil shall have brass or steel separable socket. Thermometer wells shall be stainless steel, pressure rated to match piping system design pressure; with 2 inch extension for insulated piping and threaded cap nut with chain permanently fastened to well and cap. Thermometers for air shall have an aluminum or brass duct flange.
6. Manufacturer:

   a. Ashcroft
   b. Marsh
   c. Marshalltown
   d. Miljoco
   e. Tel-Tru
   f. Trerice
   g. U.S. Gauge
   h. Weiss
   i. Weksler
   j. Wika.

E. Select scales to cover expected range of temperatures.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General Installation Requirements:

1. Install per manufacturer's instructions.
2. Coil and conceal excess capillary on remote element instruments.
3. Install gauges and thermometers in locations where they are easily read from normal operating level.
4. Do not install instrumentation when areas are under construction, except for required rough-in, taps, supports and test plugs.

B. Positive Displacement Meters:

1. Install positive displacement meters with shutoff valves on inlet and outlet. Provide full line size valved bypass with globe valve for liquid service meters.

C. Pressure Gauges:

1. Connect pressure gauges to suction and discharge side of all pumps.
2. Provide snubber for each pressure gauge.
3. Provide coil syphon for each pressure gauge connected to steam piping.

D. Thermometers:

1. Install piping system thermometers in sockets with short couplings. Enlarge pipes smaller than 2-1/2” for installation of thermometer sockets.
2. Install thermometer sockets adjacent to control system thermostat, transmitter and sensor sockets.

END OF SECTION 22 09 00

SECTION 22 10 00 - PLUMBING PIPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Pipe and Pipe Fittings.

B. Valves.

C. Check Valves.

1.2 QUALITY ASSURANCE

A. Valves: Manufacturer's name and pressure rating marked on valve body. Remanufactured valves are not acceptable.

B. Welding Materials and Procedures: Conform to ASME Code and applicable state labor regulations.

C. Welders Certification: In accordance with ANSI/ASME Sec 9 or ANSI/AWS D1.1.

D. Piping, Fittings, Valves, and Flux for Potable Water Systems: All components shall be lead free per Federal Act S.3874, Reduction of Lead in Drinking Water Act.

1.3 SUBMITTALS

A. Submit shop drawings per Section 22 05 00.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store valves in shipping containers with labeling in place.

1.5 COORDINATION DRAWINGS

A. Reference Coordination Drawings article in Section 22 05 00 for required plumbing systems electronic CAD drawings to be provided to Coordinating Contractor for inclusion into composite coordination drawings.

PART 2 - PRODUCTS

2.1 CAST IRON PIPE

A. Cast Iron; Standard Weight; Hub and Spigot Joints:
   1. Pipe: Standard weight hub and spigot cast iron soil pipe, corrosion protective coating inside and outside, CISPI 301 and CISPI Trademark.
   2. Design Pressure: Gravity Maximum Design Temperature: 180°F
   3. Joints: Compression gasket, ASTM C564.

4. Restraints: Install pipe and fittings per the Cast Iron Soil Pipe Institute's Designation 301. Restrain pipe and fittings using an engineered and tested product manufactured for restraining no-hub cast iron soil pipe. Install per manufacturer's recommendations.
5. Adapters: Heavy duty no-hub transition for joining cast iron and PVC pipe. Adapters shall be tested and certified to ASTM C 1460 and be constructed with Type 304 stainless steel shield, thickness 0.015" shield, gasket material to meet ASTM C564, 1-1/2" to 4" will be 3" wide with four 304 stainless steel bands, and 6" to 10" will be 4" wide with six 304 stainless steel bands and 3/8" 305 stainless steel hex head screws torqued to 80 inch pounds.

B. Cast Iron; Standard Weight; No-Hub Sleeve Gaskets:

1. Pipe: Standard weight no-hub cast iron soil pipe, corrosion protective coating inside and outside, CISPI 301 and CISPI Trademark.
2. Design Pressure: Gravity Maximum Design Temperature: 180°F
3. Joints: Heavy duty, neoprene sleeve gasket, ASTM C-564, 300 Series stainless steel shield, clamp, and screws with at least four screw type clamps, FM 1680 or ASTM C1540.
4. Restraints: Install pipe and fittings per the Cast Iron Soil Pipe Institute's Designation 310. Restrain pipe and fittings using an engineered and tested product manufactured for restraining no-hub cast iron soil pipe. Install per manufacturer's recommendations.
5. Adapters: Transitions from cast iron soil pipe to other pipe materials with manufactured adapters. Heavy duty neoprene sleeve gasket, ASTM C-564, 300 Series stainless steel shield, clamp, and screws with not less than four screw type clamps, FM 1680 or ASTM C1540.

2.2 COPPER PIPE

A. Copper Pipe; Type L; Solder Joints:

1. Pipe: Type L hard drawn seamless copper tube, ASTM B88.
2. Design Pressure: 175 psi; Maximum Design Temperature: 200°F.
3. Joints: Solder with 100% lead-free solder and flux, ASTM B32.
4. Fittings: Wrought copper solder joint, ANSI B16.22.

B. Copper Pipe; Type K; Solder Joints:

1. Pipe: Type K annealed copper tube, ASTM B88.
2. Design Pressure: 150 psi. Maximum Design Temperature: 200°F.
3. Joints: Solder with 100% lead-free solder and flux ASTM B32BCuP silver braze, AWS A5.8.
4. Fittings: Wrought copper solder joint, ANSI B16.22.

2.3 DUCTILE IRON PIPE

A. Ductile Iron Pipe; Pressure Water Pipe; Push-On Joints - Pressure Pipe:

1. Pipe: Ductile iron pressure water pipe, ANSI/AWWA C151/A21.51, 200 psi pressure class, cement-mortar lined per ANSI/AWWA C104/A21.4.
2. Design Pressure: 200 psi. Maximum Design Temperature: 150°F.
3. Fittings: Ductile iron, ANSI/AWWA C110/A21.10 or ANSI/AWWA C153/A21.53, 200 psi pressure class, cement-mortar lined per ANSI/AWWA C104/A21.4, push-on joints.
4. Joint: Push-on joint with rubber gasket, ANSI/AWWA C111/A21.11.

2.4 PLASTIC PIPE

A. Polypropylene (fire retardant); Schedule 40 Drainage; Electrically Fused Joints:

1. Pipe: Fire retardant polypropylene Schedule 40 drainage pipe.
2. Joints:

a. Join pipe and fittings with electrically fused joints. Make fittings between dissimilar materials with adapters furnished by the polypropylene pipe manufacturer.
b. Above Floor Only: Mechanical joint with gasket, stainless steel outer sleeve and corrosion resistant nuts and bolts or threaded fittings with gasket and compression nuts.

3. Fittings: Fire retardant polypropylene DWV pattern with socket ends for electrically fused joints. Pipe and fittings shall be a system provided by the same manufacturer.
4. Limitations: For use in non-return air plenums.
5. Special Requirements: Provide expansion loop(s) and/or expansion joints in the piping system per the manufacturer's guidelines and as shown on the drawings. Refer to Section 22 05 16 for expansion joint requirements.

B. Polypropylene (non-fire retardant); Schedule 40 Drainage; Electrically Fused Joints:

1. Pipe: Non-fire retardant polypropylene Schedule 40 drainage pipe.
2. Joints: Join pipe and fittings with electrically fused joints. Make fittings between dissimilar materials with adapters furnished by the polypropylene pipe manufacturer.
3. Fittings: Non-fire retardant polypropylene DWV pattern with socket ends for electrically fused joints. Pipe and fittings shall be a system provided by the same manufacturer.
4. Special Requirements: Provide expansion loop(s) and/or expansion joints in the piping system per the manufacturer's guidelines and as shown on the drawings. Refer to Section 22 05 16 for expansion joint requirements.

C. Polyvinylidene Fluoride (PVDF); Schedule 40 Drainage; Electrically Fused Joints:

1. Pipe: Polyvinylidene fluoride (PVDF) Schedule 40 drainage pipe, ASTM E-84, UL 723.
2. Joints:

a. Join pipe and fittings with electrically fused joints. Make fittings between dissimilar materials with adapters furnished by the polypropylene pipe manufacturer.
b. Above Floor Only: Mechanical joint with gasket, stainless steel outer sleeve and corrosion resistant nuts and bolts or threaded fittings with gasket and compression nuts.

3. Fittings: Polyvinylidene fluoride (PVDF) DWV pattern with socket ends for electrically fused joints. Pipe and fittings shall be a system provided by the same manufacturer.
4. Limitations: Allowed for use in return air plenums.
5. Special Requirements: Provide expansion loop(s) and/or expansion joints in the piping system per the manufacturer's guidelines and as shown on the drawings. Refer to Section 22 05 16 for expansion joint requirements.

D. Chlorinated Polyvinyl Chloride (CPVC); Schedule 40 Drainage; Solvent Weld Joints:

1. Pipe: Chlorinated polyvinyl chloride (CPVC) Schedule 40 drainage pipe, ASTM F1412, NSF Listed.
2. Joints: Solvent-weld socket type with solvent recommended by pipe manufacturer, ASTM F493.
3. Fittings: Chlorinated polyvinyl chloride (CPVC) DWV pattern with socket ends for Schedule 40 pipe.
4. Limitations: CPVC shall not be used in a return air plenum unless it is specifically listed to ASTM E84 and/or UL723. CAN ULC S102.2 listing is not acceptable.
5. Special Requirements: Provide expansion loop(s) and/or expansion joints in the piping system per the manufacturer's guidelines and as shown on the drawings. Refer to Section 22 05 16 for expansion joint requirements.

E. Polypropylene Piping:

1. Design Pressure 150 psi at 180°F
2. Polypropylene; SDR 7.3; Socket or Electrofusion:

a. Pipe: Multilayer extruded PP-RCT polypropylene with fiberglass layer; SDR 7.3. ASTM F2389.7.3. Shall comply with NSF/ANSI 14, CSA B137.11 and NSF/ANSI 61 for transport of drinking water.
b. Joints: Polypropylene socket fused or electrofusion.

c. Fittings: Polypropylene PP-RCT; PP-RCT/brass (for connection to brass or bronze valves).
d. Limitations: Shall not be used in a plenum unless listed ≤ 25/50 per ASTM E84/UL723.

3. Manufacturers:

a. Niron FG Clima
b. Aquatherm MF

F. Polypropylene; SDR 11 Pressure; Fusion Weld:

1. Pipe: Polypropylene SDR 11 (150 psig) SDR 17.6 (90 psig) SDR 32.5 (45 psig), ASTM D4101
2. Design Pressure/Temperature: 45 psig 90 psig 150 psig at 68°F
3. Joints:

a. Pressure fittings 1/2" through 4" shall be socket fusion type.
b. Drainage pattern fittings, and pressure fittings 2" and larger shall be butt fusion welded per ASTM D2657.
c. Pipe and fittings shall be a system provided by the same manufacturer.

4. Limitations: Not for use in return air plenums.
5. Special Requirements: Provide expansion loop(s) and/or expansion joints in the piping system per the manufacturer's guidelines and as shown on the drawings. Refer to Section 22 05 16 for expansion joint requirements.
6. Manufacturer:

a. Simtech
b. Approved equal

G. Polyvinylidene Fluoride (PVDF); SDR 11; Fusion Weld:

1. Pipe: Polyvinylidene fluoride (PVDF) SDR 7.4 (232 psig) SDR 11 (150 psig), ASTM D3222.
2. Design Pressure/Temperature - 150 psig 232 psig at 73°F
3. Joints:

a. Pressure fittings 3/8" through 1-1/2" shall be socket fusion type.
b. Drainage pattern fittings, and pressure fittings 2" and larger shall be butt fusion welded per ASTM D2657-87.
c. Pipe and fittings shall be a system provided by the same manufacturer.

4. Limitations: Not for use in return air plenums.
5. Manufacturer:

a. Simtech
b. Approved equal

H. PVC Perforated; Footing Tile; Schedule 40:

1. Pipe: Schedule 40 Perforated PVC Footing Tile - ASTM D1785/76 or DWV Perforated Footing Tile - ASTM D2665/76.

a. Manufacturers:

1) JM Eagle
2) Charlotte
3) Cresline

2. Geotextile Fabric: As recommended by the manufacturer for this application.

   a. Manufacturers:

      1) Typar
      2) Cerex
      3) Big 'O'

I. Polyethylene Corrugated; Footing Tile:

1. Pipe: Corrugated Polyethylene Footing Tile - ASTM F405.
2. Geotextile Fabric: As recommended by the manufacturer for this application.
3. Manufacturers:

   a. Typar
   b. Cerex
   c. Big 'O'

2.5 VALVES

A. Shutoff Valves:

1. Butterfly Valves:

   a. BF-1:

      1) 2-1/2" thru 6", 175 psi CWP, elastomers rated for 20°F to 250°F at 125 psig, fully lugged end, ductile or cast iron body (not in contact with fluid); bronze, aluminum-bronze or EPDM coated ductile iron disc; EPDM seat, stainless steel stem, extended neck, 175 psi bubble-tight, bi-directional dead-end shutoff without backing flange or nuts and with cap screws extending to centerline of valve body (for pipe extension without draining system), 10 position locking operator up to 6" size. Cv of at least 1580 in 6" size. Center Line Series 200, Keystone #222, Watts #DBF-03-121-1P, Stockham LD712-B&3-E, Nibco LD2000N Series, Milwaukee CL series, Hammond 5200 series.
      2) Mechanically coupled grooved end valves are acceptable if they have the features listed above. Victaulic #608, Nibco GD4765.

2. Ball Valves:

      1) BA-1: 3" and under, 150 psi saturated steam, 600 psi CWP, full port, screwed or solder ends (acceptable only if rated for soldering in line with 470°F melting point of lead-free solder), navy bronze body of a copper alloy containing less than 15% zinc, stainless steel ball and trim, Teflon seats and seals. Provide solid extended shaft for all insulated piping.
      2) Provide lock out trim for all valves opening to atmosphere installed in domestic water piping over 120°F, heating water piping over 120°F, steam, condensate, boiler feed water piping, and gasoline/kerosene piping, and as indicated on the drawings. Solid extended shaft is not required on valves with lock out trim.

B. Throttling Valves

1. Globe Valves:

   a. GL-1: 2" and under, 150# saturated steam, 300# CWP, screwed, bronze. Crane #7TF, Stockham #B22T, Walworth #3095, Milwaukee #590, Hammond #IB413T, Watts #B-4010-T, Nibco T-235Y.

2. Plug Valves:

   a. PL-1: 2" and under, 125# steam @ 450°F, 175# CWP @ 180°F, cast iron body, screwed, full port. Walworth #1700, DeZurik #425, S-RS49.
   b. PL-2: 2-1/2" thru 4", 125# steam @ 450°F, 175# CWP @ 180°F, flanged, cast iron body, full port. Walworth #1700F, DeZurik #425, F-RS49.
   c. PL-13: 2" and under, 175# CWP, 250°F elastomer, screwed, bronze body, resilient plug facing (RS-55), adjustable memory stop, non-removable lever handle. DeZurik #120-S.
   d. PL-15: 2-1/2" thru 8", 150# CWP, 250°F elastomer, flanged, bronze body, resilient plug facing (RS-55 or RS-56), adjustable memory stop. DeZurik #120-F.

2.6 STRAINERS

A. All strainers to come with blow down valve and hose thread end and cap with chain.

B. ST-1: Bronze body, screwed ends, screwed cover, 150 psi S @ 350°F, 200 psi CWP @ 150°F. Armstrong #F4SC, Metraflex #TS, Mueller Steam Specialty Co. #351, Sarco #BT, Watts #777.

C. ST-7: 2-1/2" thru 8", bronze body, flanged ends, flanged cover, 150# steam, 225# CWP. Mueller Steam Specialty Co. #851.

2.7 CHECK VALVES

A. CK-1: 2" and under, 125# steam @ 406°F, 200# CWP @ 150°F, screwed, bronze, horizontal swing. Crane #37, Hammond #IB904, Stockham #B319-Y, Walworth #3406, Milwaukee #509, Watts #G-5000, Nibco T-413B.

B. CK-13: 2-1/2" thru 12", 200# CWP, double disc wafer type, iron body, bronze or aluminum-bronze discs, 316SS shaft and spring, Viton, EPDM or BUNA-N, Cv of at least 700 in 6" size. Mueller Steam Specialty Co. #71-AHB-6-H, Stockham #WG-961 EPDM or #WG-970 BUNA, NIBCO W-920-W, Crane.

C. CK-14: 2-1/2" thru 12", 200# CWP, double disc wafer type, bronze or iron body, bronze trim, metal-to-metal or Viton seat, 316 SS shaft, Inconel 600 spring. Mission Duo Chek #12HPP (with Inconel springs), Mueller Steam Specialty Co. #71-AHB-K-W, Stockham #WG-961-EPDM or #WG-970-BUNA, Nibco w-920-W.

D. CK-20: 2" and larger, 125# CWP, flanged, iron body, cast iron or carbon steel body with stainless steel internals. Hoerbiger Design "CT". Note: Use only for compressor discharge.

2.8 LOCK OUT TRIM

A. Provide lock out trim for all quarter turn shutoff valves opening to atmosphere and installed in domestic water piping over 120°F and as indicated on the drawings.

2.9 VALVE OPERATORS

A. Provide handwheels for gate valves and gear operators for butterfly valves.

2.10 VALVE CONNECTIONS

A. Provide all connections to match pipe joints. Valves shall be same size as pipe unless noted otherwise.

2.11 CONNECTIONS BETWEEN DISSIMILAR METALS

A. Connections between dissimilar metals shall be insulating dielectric types that provide a water gap between the connected metals, and that either allow no metal path for electron transfer or that provide a wide water gap lined with a non-conductive material to impede electron transfer through the water path.

B. Joints shall be rated for the temperature, pressure, and other characteristics of the service in which they are used, including testing procedure.

C. Aluminum, iron, steel, brass, copper, bronze, galvanized steel and stainless steel are commonly used and require isolation from each other with the following exceptions:

1. Iron and steel connected to each other.
2. Brass, copper, and bronze connected to each other.
3. Brass or bronze valves and specialties connected in closed systems with steel, iron, or stainless steel on both sides of the brass or bronze valves and specialties. Where two or more brass or bronze items occur together, they shall be connected with brass nipples. Brass or bronze valves and specialties cannot be used as a dielectric separation between pipe materials.

D. Dielectric protection is required at connections to equipment of a material different than the piping.

E. Screwed Joints (acceptable up to 2" size):

1. Dielectric waterway rated for 300 psi CWP and 225°F.
2. Manufacturers:

a. Elster Group ClearFlow fittings
b. Victaulic Series 647
c. Grinnell Series 407
d. Matco-Norca

F. Flanged Joints (any size):

1. Use 1/8" minimum thickness, non-conductive, full-face gaskets.
2. Employ one-piece molded sleeve-washer combinations to break the electrical path through the bolts.
3. Sleeve-washers are required on one side only, with sleeves minimum 1/32" thick and washers minimum 1/8" thick.
4. Install steel washers on both sides of flanges to prevent damage to the sleeve-washer.
5. Separate sleeves and washers may be used only if the sleeves are manufactured to exact lengths and installed carefully so the sleeves must extend partially past each steel washer when tightened.
6. Manufacturers:

a. EPCO
b. Central Plastics
c. Pipeline Seal and Insulator
d. F. H. Maloney
e. Calpico

PART 3 - EXECUTION

3.1 PREPARATION

A. Install all products per manufacturer's recommendations.

B. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.

C. Remove scale and dirt, on inside and outside, before assembly.

D. Remove all scale, rust, dirt, oils, stickers and thoroughly clean exterior of all bare metal exposed piping, hangers, and accessories in preparation to be painted.

E. Connect to equipment with flanges or unions.

F. Use only piping materials rated for the maximum temperature of the application, e.g., do not use PVC for dishwasher drainage or piping that receives boiler blowdown.

G. Roof Penetration (Vent) Flashing:

1. Built-up Roofing: Flash vents with 3# seamless sheet lead of sufficient size to extend 15" into roofing felts for built-up roofs.
2. Membrane, Metal or Shingled Roofs: Flash vents with premolded pipe flashing cones for single-ply membrane roofs, metal roofs, or shingled roofs.

H. Existing building sewers or building drains which are shown on the documents to be reused shall be inspected and recorded by closed circuit television for their condition. Report findings back to the Architect, Engineer, and Owner before proceeding with work so any necessary rework can take place if needed.

3.2 SYSTEM, PIPING AND VALVE SCHEDULE

A. Cold Water, Hot Water, Tempered Water - Potable and Non-Potable (Above Ground):

1. Copper Pipe; Type L; Solder Joints: All Sizes
2. Shutoff Valves: BF-1, BA-1
3. Throttling Valves: GL-1
4. Check Valves: CK-1, CK-14
5. Strainers: ST-1, ST-7

B. Cold Water, Hot Water, Tempered Water - Potable and Non-Potable (Underground):

1. Copper Pipe; Type K; Solder Joints: All Sizes

C. Vacuum, Instrument Air, Nitrogen (Non-Medical):

1. Copper Pipe; Type L; Solder Joints: All Sizes
2. Shutoff Valves: BA-1, PL-13, PL-15
3. Throttling Valves: GL-1
4. Check Valves: CK-1, CK-20
5. Strainers: ST-1, ST-7

D. Sanitary Waste and Vent, Gravity (Above Ground):

1. Cast Iron; Standard Weight; No-Hub Sleeve Gaskets: 1-1/2" to 15"

E. Sanitary Indirect Drainage (Above Ground):

1. Cast Iron; Standard Weight; No-Hub Sleeve Gaskets: 1-1/2" to 15"

F. Storm Drainage, Gravity (Above Ground):

1. Cast Iron; Standard Weight; No-Hub Sleeve Gaskets: 1-1/2" to 15"

G. Sanitary Waste and Vent, Gravity (Underground - Inside Building):

1. Cast Iron; Standard Weight; Hub and Spigot Joints: All Sizes

H. Storm Drainage, Gravity (Underground - Inside Building):

1. Cast Iron; Standard Weight; Hub and Spigot Joints: All Sizes

I. Sanitary Waste - Pumped (Underground - Outside Building)

1. Ductile Iron Pipe; Pressure Water Pipe; Push-On Joints - Pressure Pipe: All Sizes

J. Storm - Pumped (Underground - Outside Building):

1. Ductile Iron Pipe; Pressure Water Pipe; Push-On Joints - Pressure Pipe: All Sizes

K. Sanitary Waste - Pumped (Underground - Inside Building):

1. Copper Pipe; Type K; Solder Joints: All Sizes

L. Storm - Pumped (Underground - Inside Building):

1. Copper Pipe; Type K; Solder Joints: All Sizes

M. Sanitary Waste - Pumped (Above Ground - Inside Building):

1. Copper Pipe; Type K; Solder Joints: All Sizes
2. Galvanized Steel; Standard Weight; Threaded Joints: 4" and under
3. Shutoff Valves: BA-1, BA-1A, BF-1, GA-7
4. Check Valves: CK-1, CK-13

N. Storm - Pumped (Above Ground - Inside Building):

1. Copper Pipe; Type K; Solder Joints: All Sizes
2. Galvanized Steel; Standard Weight; Threaded Joints: 4" and under
3. Shutoff Valves: BA-1, BA-1A, BF-1, GA-7
4. Check Valves: CK-1, CK-13

O. Acid Waste and Vent:

1. Polypropylene (fire retardant); Schedule 40 Drainage; Electrically Fused Joints: All Sizes
2. Polypropylene (non-fire retardant); Schedule 40 Drainage; Electrically Fused Joints: All Sizes
3. Polyvinylidene Fluoride (PVDF); Schedule 40 Drainage; Electrically Fused Joints: All Sizes
4. Chlorinated Polyvinyl Chloride (CPVC); Schedule 40 Drainage; Solvent Weld Joints: All Sizes

P. Condensate/Equipment Drainage:

1. Cast Iron; Standard Weight; Hub and Spigot Joints: All Sizes
2. Cast Iron; Standard Weight; No-Hub Sleeve Gaskets: 1-1/2" to 15"
3. Copper Pipe: Type DWV; Solder Joints: 1-1/4" to 4"
4. PVC-DWV or ABS-DWV; Schedule 40; Solvent Weld Joints: All Sizes

Q. Footing Tile:

1. PVC Perforated; Footing Tile; Schedule 40: All Sizes
2. Polyethylene Corrugated; Footing Tile: All Sizes

3.3 TESTING PIPING

A. Sanitary Drainage, Sanitary Vent, Storm Drainage, Acid Waste, Acid Vent:

1. Test all piping with water to prove tight.
2. Test piping before insulation is applied.
3. Hydrostatically test all soil, waste, and vent piping inside of building with 10 feet head of water for 15 minutes. Inspect before fixtures are connected. If leaks appear, repair them and repeat the test.
4. Hydrostatically test interior downspouts with 10 feet head of water for 15 minutes with no leaks.
5. A smoke/air test at the same pressure may be used in lieu of the hydrostatic water test. Exception: Smoke/air test shall not be performed on plastic piping.
6. Test force mains with water at 105% of the operating pump discharge pressure for 15 minutes.
7. Test pressures stated above shall be as listed or as required by the Authority Having Jurisdiction, whichever is most stringent.

B. Hot Water - Potable and Non-Potable, Cold Water - Potable and Non-Potable, Tempered Water - Potable and Non-Potable, Service Water:

1. Test pipes underground or in chases and walls before piping is concealed.
2. Test all pipes before the insulation is applied. If insulation is applied before the pipe is tested and a leak develops which ruins the insulation, replace damaged insulation.
3. Test the pipe with 100 psig water pressure or equal inert gas such as nitrogen. Exception: Inert gas test shall not be used to test plastic piping.
4. Hold test pressure for at least 2 hours.
5. Test to be witnessed by the Architect/Engineer's representative, if requested by the Architect/Engineer.

C. Fire Service:

1. Hydrostatically test the entire system for two hours at 200 psig. Maximum leakage shall be:

    a. Interior Piping: 0 quarts per hour.
    b. Underground Piping: 2 quarts per 100 joints per hour.

D. Vacuum, Instrument Air and Nitrogen Piping:

1. Testing pipes in chases, walls, or above non-accessible ceilings before piping is concealed.
2. Test with 100 psig compressed air or nitrogen.
3. During the test, strike all soldered joints sharply with a rubber or rawhide mallet to cause failure of any weak joints. After striking, soap test each joint.
4. Repair and retest all leaking joints.
5. After all joints pass the soap test, the system must maintain test pressure for 24 hours. If system fails the 24-hour, retest ALL joints by resoaping and repair all faulty joints. Repeat this procedure until the test pressure can be maintained for 24 hours.
6. After passing the above test, operate the vacuum pump. With all vacuum valves closed, the pump and piping system shall be able to maintain a vacuum of 25" Hg for at least one hour.
7. All materials, labor and equipment for testing shall be provided by the installing Contractor.
8. Tests to be witnessed by the Architect/Engineer's representative, if requested by the Architect/Engineer.
9. After testing, seal the complete system against entry of foreign material until it is turned over to the Owner.

E. All Other Piping:

1. Test piping at 150% of normal operating pressure.
2. Piping shall hold this pressure for one hour with no drop in pressure.
3. Test piping using water, nitrogen, or air as compatible with the final service of the pipe. Do not use combustible fluids.
4. Drain and clean all piping after testing is complete.

3.4 CLEANING PIPING

A. Assembly:

1. Before assembling pipe systems, remove all loose dirt, scale, oil and other foreign matter on internal or external surfaces by means consistent with good piping practice subject to approval of the Architect/Engineer's representative. Blow chips and burrs from machinery or thread cutting operation out of pipe before assembly. Wipe cutting oil from internal and external surfaces.
2. During fabrication and assembly, remove slag and weld spatter from both internal and external joints by peening, chipping and wire brushing.
3. Notify the Architect/Engineer's representative before starting any post erection cleaning in sufficient time to allow witnessing the operation. Consult with and obtain approval from the Architect/Engineer's representative regarding specific procedures and scheduling. Dispose of cleaning and flushing fluids properly.
4. Prior to blowing or flushing erected piping systems, disconnect all instrumentation and equipment, open wide all valves, and be certain all strainer screens are in place.

B. Air Blow:

1. Blow out pipe and components with clean compressed air. Instrument air, argon, nitrogen and sulfuric acid lines shall be blown out with dry, oil free air or nitrogen gas. "Oil Free" is defined as air compressed in a centrifugal, Teflon ring, carbon ring or water pumped air compressor. Where air supply is judged to be inadequate to continually attain cleaning velocity, alternate pressurization and sudden relief procedure may be used until discharge at all blow out points is clean. Use 80-90 psig pressure unless otherwise indicated.
2. Air blow applies to the following systems:

a. Acetylene
b. Carbon Dioxide
c. Nitrogen (use oil free air or nitrogen gas)
d. Argon (use oil free air or nitrogen gas)
e. Instrument Air (use oil free air or nitrogen gas)
f. Distilled Water (use maximum of 50 psig pressure)
g. Chemical Feed
h. Air Compressor Intakes
i. Sulfuric Acid (use oil free air or nitrogen gas)

C. All Water Piping:

1. Flush all piping using faucets, flush valves, etc. until the flow is clean.
2. After flushing, thoroughly clean all inlet strainers, aerators, and other such devices.
3. If necessary, remove valves to clean out all foreign material.

D. Fire Service:

1. Flush all underground piping with minimum flow equal to the system design flow but not less than the following:

a. 390 gpm for 4" pipes.
b. 880 gpm for 6" pipes.
c. 1560 gpm for 8" pipes.
d. 2440 gpm for 10" pipes.
e. 3500 gpm for 12" pipes.

3.5 INSTALLATION

A. General Installation Requirements:

1. Provide dielectric connections between dissimilar metals.

2. Route piping in orderly manner and maintain gradient. Install to conserve building space.
3. Group piping whenever practical at common elevations.
4. Install piping to allow for expansion and contraction without stressing pipe, joints, or equipment.
5. Slope water piping and arrange to drain at low points.
6. Install bell and spigot piping with bells upstream.
7. Where pipe supports are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welds.
8. Seal pipes passing through exterior walls with a wall seal per Section 22 05 29. Provide Schedule 40 galvanized sleeve at least 2 pipe sizes larger than the pipe.
9. All non-potable outlets shall be clearly marked with a permanently affixed laminated sign with 3/8" high lettering saying "Non-Potable Water Not for Human Consumption." Sign shall have black lettering on a yellow background.
10. All vertical pipe drops to sinks or other equipment installed below the ceiling shall be routed within a wall cavity, unless specifically noted otherwise to be surface mounted. For renovation projects, this Contractor is responsible for opening and patching existing walls for installation of piping. Wall patching shall match existing condition.

B. Installation Requirements in Electrical Rooms:

1. Do not install piping or other equipment above electrical switchboards or panelboards. This includes a dedicated space extending 25 feet from the floor to the structural ceiling with width and depth equal to the equipment.

C. Installation Requirements in MRI (Magnetic Resonance Imaging - Healthcare):

1. All piping in MRI rooms shall be non-ferrous regardless of materials described on Part 2.

D. Valves/Fittings and Accessories:

1. Install shutoff valves that permit the isolation of equipment/fixtures in each room without isolating any other room or portion of the building. Individual fixture angle stops do not meet this requirement. Exception: Back-to-back rooms in no more than two adjacent rooms.
2. Provide clearance for installation of insulation and access to valves and fittings.
3. Provide access doors for concealed valves and fittings.
4. Install valve stems upright or horizontal, not inverted.
5. Provide one plug valve wrench for every ten plug valves 2" and smaller, minimum of one. Provide each plug valve 2-1/2" and larger with a wrench with set screw.
6. Install corrugated, stainless steel tubing system according to manufacturer's written instructions. Include striker plates to protect tubing from puncture where tubing is restrained and cannot move.

E. Underground Piping:
1. Install buried water piping outside the building with at least 5 feet of cover. Refer to Section 22 05 00 for Excavation, Fill, Backfill and Compaction requirements
2. Install buried borosilicate glass pipe with the protective polystyrene covering intact. Lay the pipe on bedding and backfill per manufacturer instructions.
3. Underground fire protection service piping shall have at least 6-1/2 feet of cover, or as recommended by NFPA 24.
4. Install thrust blocking and restraints on all underground fire protection service piping per NFPA 24 and as shown on drawings.
5. Install underground, sleeved, corrugated, stainless steel tubing system according to manufacturer's written instructions. Extend vent from sleeve to exterior of building and terminate with screened elbow.
6. Direct buried, uninsulated steel pipe shall have a factory applied external protective coating consisting of two coats with an intermediate layer of 18 mil fibrous glass mat. Coating thickness shall total not less than 3/32". The outer coating shall be further protected by a wrapping of heavy Kraft paper. This external protection shall extend and be exposed for a minimum of 1 foot beyond the buried or concealed portion of the pipe.

   a. Manufacturers:

      1) Pipe Line Service Co. Franklin Park, Illinois

2) Lithcote Corp., Melrose Park, Illinois

7. As an option, the Contractor may provide factory applied protective coatings consisting of a polyethylene plastic film bonded to the pipe surface by a hot applied thermo-plastic adhesive.

a. Manufacturers:

1) Republic Steel Corp. "X-Tru-Coat"

8. Exercise care in handling, storing and laying pipe to avoid damaging factory applied coatings. If any damage occurs, repair the coating to a condition equal to the original.
9. Field application of protective coatings to joints, fittings and to any damaged factory applied coatings shall be similar to factory applied coatings specified above and shall be done in strict accordance with recommendations of the supplier of pipe coatings.
10. After completion of the fabrication, laying and field coating of the joints and fittings, but prior to backfilling, inspect the entire line in the presence of the Architect/Engineer's representative with an electronic holiday detector. Any defects in the protective coatings shall be repaired in accordance with requirements for original coatings.
11. Coat flange bolts and nuts in pits and below ground at the time of installation with a corrosion protective coating.

F. Sanitary and Storm Piping:

1. Install all sanitary and storm piping inside the building with a slope as shown on the drawings.
2. Install horizontal offset at all connections to roof drains to allow for pipe expansion.
3. Slope sanitary and storm piping outside the building to meet invert elevations shown on drawings and to maintain a minimum velocity of 2 feet per second.
4. Sway Bracing: Where horizontal sanitary and/or storm pipes 4 inches and larger change flow direction greater than 45°, rigid bracing or thrust restraints shall be installed to resist movement of the upstream pipe in the direction of pipe flow. The rigid bracing or thrust restraint shall be connected to structure. A change of flow direction from horizontal into a vertical pipe does not require the upstream pipe to be braced.
5. All sanitary and storm piping shall have at least 42" of cover when leaving the building.
6. Starter fittings with internal baffles are not permitted.

3.6 PIPE ERECTION AND LAYING

A. Carefully inspect all pipe, fittings, valves, equipment and accessories before installation. Any items that are unsuitable, cracked or otherwise defective shall be removed from the job immediately.

B. All pipe, fittings, valves, equipment and accessories shall have factory applied markings, stampings, or nameplates with sufficient data to determine their conformance with specified requirements.

C. Exercise care at every stage of storage, handling, laying and erecting to prevent entry of foreign matter into piping, fittings, valves, equipment and accessories. Do not install any item that is not clean.

D. Until system is fully operational, all openings in piping and equipment shall be kept closed except when actual work is being performed on that item or system. Closures shall be plugs, caps, blind flanges or other items specifically designed and intended for this purpose.

E. Run pipes straight and true, parallel to building lines with minimum use of offsets and couplings. Provide only offsets required to provide needed headroom or clearance and to provide needed flexibility in pipe lines.

F. Make changes in direction of pipes only with fittings or pipe bends. Changes in size only with fittings. Do not use miter fittings, face or flush bushings, or street elbows. All fittings shall be of the long radius type, unless otherwise shown on the drawings or specified.

G. Provide flanges or unions at all final connections to equipment, traps and valves.

H. Arrange piping and connections so equipment served may be totally removed without disturbing piping beyond final connections and associated shutoff valves.

I. Use full and double lengths of pipe wherever possible.

J. Unless otherwise indicated, install all piping, including shutoff valves and strainers, to coils, pumps and other equipment at line size with reduction in size being made only at control valve or equipment.

K. Cut all pipe to exact measurement and install without springing or forcing except in the case of expansion loops where cold springing is indicated on the drawings.

L. Underground pipe shall be laid in dry trenches maintained free of accumulated water. Refer to Section 22 05 00 for Excavation, Fill, Backfill and Compaction requirements.

M. Unless otherwise indicated, branch take-offs shall be from top of mains or headers at either a 45° or 90° angle from the horizontal plane for air lines, and from top, bottom or side for liquids.

N. Do not use geotextile fabric with footing tile if silt content of soil exceeds 40% or if clay content exceeds 50%. The fabric shall be installed around 1" river rock or 2" limestone.

3.7 DRAINING AND VENTING

A. Unless otherwise indicated on the drawings, all horizontal water lines, including branches, shall pitch 1" in 40 feet to low points for complete drainage, removal of condensate and venting.

B. Maintain accurate grade where pipes pitch or slope for venting and drainage. No pipes shall have pockets due to changes in elevation.

C. Provide drain valves at all low points of water piping systems for complete or sectionalized draining.

D. Use eccentric reducing fittings on horizontal runs when changing size of pipes for proper drainage and venting. Install gravity drain pipes with bottom of pipe and eccentric reducers in a continuous line; all other liquid lines with top of pipe and eccentric reducers in a continuous line.

E. Provide air vents at high points and wherever else required to eliminate air in all water piping systems.

F. Install air vents in accessible locations. If necessary to trap and vent air in a remote location, install an 1/8" pipe from the tapping location to an accessible location and terminate with a venting device.

G. All vent and drain piping shall be of same materials and construction for the service involved.

3.8 PLUMBING VENTS

A. Vent as shown on the drawings and in accordance with all codes having jurisdiction.

B. Extend the high side of the soil and waste stacks at least 12" above roof.

C. Flash pipes at the roof with 3# lead sheet. Extend flashing under roofing 15" in all directions from pipe to be flashed. Extend a lead collar up on the outside of pipe to be flashed and extend 1" beyond the top of the pipe. The 1" excess length of collar shall be turned down into the top of the pipe where it shall fit tight to the inside of the pipe.

D. Flash pipes at roof with premolded EPDM pipe flashing cones adhered to roof membrane by General Contractor. Secure top of cone with stainless steel clamp and seal watertight.

E. Increase vent pipes through the roof two pipe sizes with long increasers located at least 12” below the roof.

F. In no case shall the vent through the roof be less than 4" in diameter.

G. Vent pipes through the roof shall be located a minimum of from any air intake opening on the roof.

3.9 BRANCH CONNECTIONS

A. For domestic water and vent systems only, make branch connections with standard tee or cross fittings of the type required for the service.

B. Reducers are generally not shown. Where pipe sizes change at tee, the tee shall be the size of the largest pipe shown connecting to it.

C. Do not use double wye or double combination wye and eighth bend DWV fittings in horizontal piping.

D. Branch connections from the headers and mains may be mechanically formed using an extraction device. The branch piping connection shall be brazed connection for the following services only:

1. Domestic water piping above ground.

E. Further limit use of mechanically formed fittings as follows:

1. Must have at least same pressure rating as the main.
2. Main must be Type K or L copper tubing.
3. Permanent marking shall indicate insertion depth and orientation.
4. Branch pipe shall conform to the inner curve of the piping main.
5. Main must be 1" or larger.
6. Branch must be 3/4" or larger.

F. Branch connections from headers and mains may be cut into black steel pipe using forged weld-on fittings.

G. Forged weld-on fittings are limited as follows:

1. Must have at least same pressure rating as the main.
2. Main must be 2-1/2" or larger.
3. Branch line is at least two pipe sizes under main size.

3.10 JOINING OF PIPE

A. Threaded Joints (Galvanized Steel Pipe):

1. Threads shall conform to ANSI B2.1 "Pipe Threads".
2. Ream pipe ends and remove all burrs and chips formed in cutting and threading.
3. Protect plated pipe and valve bodies from wrench marks when making up joints.
4. Apply thread lubricant to male threads as follows:

   a. Vents and Roof Conductors: Red graphite
   b. All Other Services: Teflon tape

B. Flanged Joints (Galvanized Steel Pipe):

1. Steel pipe flanges shall conform to ANSI B16.5 "Steel Pipe Flanges and Flanged Fittings". Cast iron pipe flanges shall conform to ANSI B16.1 "Cast Iron Flanged and Flanged Fittings". Steel flanges shall be raised face except when bolted to flat face cast iron flange.
2. Bolting for services up to 500°F shall be ASTM A307 Grade B with square head bolts and heavy hexagonal nuts conforming to ANSI B18.2.1 "Square and Hex Bolts" and B18.2.2 "Square and Hex Nuts".

3. Set flange bolts beyond finger tightness with a torque wrench for equal tension in all bolts. Tighten bolts so those 180° apart are torqued in sequence.
4. Gaskets for flat face flanges shall be full face type. Gaskets for raised faced flanges shall conform to requirements for "Group I Gaskets" in ANSI B16.5. Unless otherwise specified gaskets shall meet the following requirements:

   a. Gasket material and thickness approved by manufacturer for intended service, chemical compatibility, pipe system test pressure, and operating temperature range.
   b. Maximum pressure rating of at least 250 psig
   c. Minimum temperature rating: -10°F.
   d. Maximum temperature rating of at least 170°F for water systems operating 140°F and less.

C. Solder Joints (Copper Pipe):

1. Make up joints with 100% lead-free solder, ASTM B32. Cut tubing so ends are perfectly square and remove all burrs inside and outside. Thoroughly clean sockets of fittings and ends of tubing to remove all oxide, dirt and grease just prior to soldering. Apply flux evenly, but sparingly, over all surfaces to be joined. Heat joints uniformly so solder will flow to all mated surfaces. Wipe excess solder, leaving a uniform fillet around cup of fitting.
2. Flux shall be non-acid type.
3. Solder end valves may be installed directly in the piping system if the entire valve is suitable for use with 470°F melting point solder. Remove discs and seals during soldering if they are not suitable for 470°F.

D. Brazed Joints (Copper Pipe):

1. Make up joints with silver alloy brazing filler metal conforming to ASTM B260 "Brazing Filler Metal" BAg-1 or BAg-2. Cut copper tubing so ends are perfectly square and remove all burrs inside and outside. Thoroughly clean sockets of fittings and ends of tubing to remove all oxide, dirt and grease just prior to brazing. Apply non-corrosive flux of the type recommended by filler alloy manufacturer, evenly, but sparingly, over all surfaces to be joined. Heat joints uniformly using oxygen-acetylene torch with tip size recommended by fitting manufacturer. Wipe and brush joint clean after alloy has set.
2. Remove discs from solder end valves during brazing.

E. Welded Joints (Galvanized Steel Pipe):

1. Welding of all pipe joints, both as to procedures and qualification of welders, shall be in accordance with Section IX, ASME "Boiler & Pressure Vessel Code" unless mandatory local codes take precedence.
2. Furnish to the Owner's Representative prior to start of work certificates qualifying each welder.
3. The Owner's Representative reserves the right to require qualifying demonstration, at the Contractor's expense, of any welders assigned to the job.
4. Ends of pipe and fittings to be joined by butt welding shall be beveled, cleaned to bare metal and internal diameters aligned before tack welding.
5. Single-welded butt joints may be employed with or without the use of backing rings in all sizes. Where backing rings are not used on pumped pressurized systems, the root side of the weld shall either be chipped or ground flush with the piping wall. For services such as vents, overflows, and gravity drains, the backing ring may be eliminated, and the root of the weld need not be chipped or ground. Backing rings shall be of the material being welded.

F. Push-On Joints - Pressure Pipe (Ductile Iron, PVC Pressure):

1. Joints shall be single gasket type conforming to ANSI A21.11 "Rubber Gasket Joints for Ductile Iron Pressure Pipe and Fittings". The bell shall have cast or machined gasket socket recesses, a tapered annular opening and flared socket design to provide deflections up to 5°. Plain spigot ends shall be suitably beveled for easy entry into bell, centering in gasket and compression of gasket.
2. The joint shall be liquid tight under all pressures from vacuum to 350 psig.

3. Furnish sufficient lubricant for a thin coat on each spigot end. Lubricant shall be non-toxic, impart no taste or odor to conveyed liquid, and have no deleterious effect on the rubber gasket. Lubricant shall be of such consistency that it can be easily applied to the pipe in hot and cold weather and shall adhere to either wet or dry pipe.
4. Assemble per manufacturer's installation instructions.

G. Hub and Spigot Joints - Sanitary Pipe and Storm Pipe (Cast Iron and Stainless Steel Pipe):

1. Lead and Oakum Joints: Pack joint with oakum made of vegetable fiber, cotton, or hemp. Pour joint with molten lead up to top of hub. Ensure leak-free joints by working joint with inside and outside caulking irons.
2. Compression Gasket Joints: Joint shall be one-piece double seal compression type gasket made specifically for joining cast iron soil pipe. Gasket shall be neoprene, permitting joint to flex as much as 5 degrees without loss of seal. Gasket shall be extra heavy weight class, conforming to ASTM C-564.

H. Solvent Weld Joints (CPVC):

1. Make joints with a one-step process. Use CPVC cement conforming to ASTM F493. A primer is not required.
2. If a primer is required by the Authority Having Jurisdiction, then a primer conforming to ASTM F656 shall be used.

I. Fusion Weld (Polypropylene and PVDF):

1. Make all field cuts of pipe square and true using a pipe cutter designed for plastic pipe.
2. Make sure proper heating heads are used for male and female situations.
3. Bevel the leading edge of pipe section with a 45° chamfer.
4. Utilize a fusion welding tool recommended and/or provided by the pipe and fitting manufacturer.
5. Not recommended for temperatures below 40°F.
6. All installers shall undergo training provided by the manufacturer or manufacturer's representative.
7. Follow all manufacturer's installation instructions.

J. Polypropylene Socket or Electrofusion:

1. Polypropylene fitting shall be made in accordance with the manufacturer's installation instructions.

K. Electrically Fused Joints (Acid Waste and Acid Vent):

1. Fused joints shall be made in accordance with manufacturer's installation instructions.
2. All installers shall undergo training provided by the manufacturer or manufacturer's representative.
3. Follow the manufacturer's cold weather installation procedures.

L. No-Hub Sleeve Gaskets (No-Hub) (Cast Iron Pipe):

1. Gasket shall be heavy weight class, conforming to ASTM C564.
2. The gasket shall have an internal center stop.
3. The gasket shall be covered by a stainless steel band secured with a minimum of four stainless steel bands per fitting/joint.
4. Sleeve gaskets shall be installed in accordance with the manufacturer's installation instructions.

3.11 DISINFECTION OF DOMESTIC WATER PIPING SYSTEM

A. Disinfection of the domestic water piping shall be completed within three (3) weeks prior to building occupancy. Contractor is responsible for disinfecting water piping if used by workers during construction; disinfection during construction does not eliminate the requirement for final disinfection prior to occupancy. Flushing of piping shall be completed within two (2) weeks prior to building occupancy.

B. Provide necessary connections at the start of individual sections of mains for adding chlorine.

C. Before starting work, verify system is complete, flushed and clean.

D. 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).

E. Inject disinfectant, free chlorine in liquid, powder, tablet or gas form, throughout system to obtain 50 to 80 mg/L residual.

F. Bleed water from all outlets to ensure chlorine distribution throughout the entire domestic water system.

G. Verify initial chlorination levels by testing at minimum 15% of outlets located throughout entire building, including the last fixture connected to each main and each branch extending over 50 feet from a main.

H. Maintain disinfectant in system for 24 hours, after which test at minimum 15% of outlets located throughout entire building, including the last fixture connected to each main and each branch extending over 50 feet from a main. If final disinfectant residual tests less than 25 mg/L at any one of the tested outlets, flush the entire system and repeat disinfection and testing procedure.

I. After final disinfectant residuals test at or above 25 mg/L after a minimum 24-hour duration, flush disinfectant from system at a minimum velocity of 3.0 feet/second until residual is equal to that of incoming water or 1.0 mg/L.

J. Take water samples, no sooner than 24 hours after flushing, from 2% of outlets and from water entry. Obtain, analyze, and test samples in accordance with AWWA C651, Section 5 - Verification.

3.12 SERVICE CONNECTIONS

A. Provide new sanitary and/or storm sewer services. Before commencing work check invert elevations needed for sewer connections, confirm inverts and verify these can be properly connected with slope for drainage and cover to avoid freezing.

B. Provide new water service with water meter with bypass valves. Provide sleeve in wall for service main per Section 22 05 29.

END OF SECTION 22 10 00

SECTION 22 10 23 - NATURAL GAS AND PROPANE PIPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Pipe and Pipe Fittings.

B. Valves.

C. Natural Gas Piping System.

1.2 QUALITY ASSURANCE

A. Valves: Manufacturer's name and pressure rating marked on valve body. Remanufactured valves are not acceptable.

B. Welding Materials, Procedures, and Operators: Conform to ASME Section 9, ANSI/AWS D1.1, and applicable state labor regulations.

C. Welders Certification: In accordance with ANSI/ASME Sec 9 or ANSI/AWS D1.1.

1.3 SUBMITTALS

A. Submit product data under provisions of Section 22 05 00. Include data on pipe materials, fittings, valves, and accessories.

B. Test Reports: Provide results of piping system pressure test.

C. Welders Certificates: Certify welders employed on the Work, verifying AWS qualification within previous 12 months.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Store and protect piping to prevent entrance of foreign matter into pipe and to prevent exterior corrosion.

B. Deliver and store valves in shipping containers with labeling in place.

1.5 COORDINATION DRAWINGS

A. Reference Coordination Drawings article in Section 22 05 00 for the required natural gas piping system electronic CAD drawings to be provided to Coordinating Contractor for inclusion into composite coordination drawings.

PART 2 - PRODUCTS

2.1 NATURAL GAS (0 to 125 PSI)

A. Design Pressure: 125 psi. Maximum Design Temperature: 350°F

B. Piping - 2" and Under:

1. Pipe: Standard weight steel, threaded and coupled, ASTM A53.
2. Joints: Screwed. (NOTE: For below ground, all sizes to have welded joints.)
3. Fittings: 150# steam - 300# CWP, black malleable iron, banded, ASTM A197, ANSI B16.3.
4. Unions: 250# - 500# CWP, black malleable iron, ANSI B16.39, ground joint with brass seat.

C. Piping - 2" and Under:

1. Pipe: Corrugated stainless steel tubing, ASTM A240 Series 300 stainless steel, ANSI AGA-LC1.
2. For use when making final connection to equipment. Corrugated steel tubing not to be used in wall or above ceiling.
3. Jacket: UV resistant, electrically conductive polyethylene, color: black, ASTM E84 25-50 flame and smoke.
4. Fittings: Brass with mechanical ends to fit tubing. ASME B1.20.1 threaded ends for connections to threaded pipes and components.
5. Striker Plates: Minimum 16 gauge hardened steel, corrosion resistant, primed and zinc coated. Install to protect tubing from penetrations.
6. Limits: 5 psi or less.
7. Manufacturers:

a. TracPipe (Counterstrike)
b. Gastite (Flash Shield)

D. Piping - 2-1/2" and Over:

1. Pipe: Standard weight steel, beveled ends, ASTM A53.
2. Joints: Butt welded or flanged.
3. Fittings: Standard weight seamless steel, butt weld type, ASTM A234, Grade I, ANSI B16.9.
4. Flanges: 150# forged steel, weld neck or slip-on, ASTM A181, Grade I, ANSI B16.5. Flange face seal weld (backweld) is required for slip-on flanges.

E. Shutoff Valves/Throttling Valves:

1. BA-13: 2" and under, threaded 600 psi CWP; UL listed for 250# LP, flammable liquid, heating oil, natural and manufactured gases, 150 psi steam, bronze body and chrome plated brass ball, Teflon seats and packing.

a. Manufacturers:

1) Apollo #80-100
2) Nibco #T580-70-UL or #T585-70-UL
3) Watts #B-6000

2. PL-1: 2" and under, 125# steam @ 450°F, 175# CWP @ 180°F, cast iron body, screwed, full port.

a. Manufacturers:

1) Walworth #1700
2) DeZurik #425, S-RS49

3. PL-2: 2-1/2" thru 4", 125# steam @ 450°F, 175# CWP @ 180°F, flanged, cast iron body, full port.

   a. Manufacturers:

      1) Walworth #1700F
      2) DeZurik #425, F-RS49

4. PL-3: 6" and larger, 125# steam @ 450°F, 175# CWP, cast iron body, flanged, resilient faced plug, gear and handwheel operator, full port.

   a. Manufacturers:

      1) Walworth #1707F
      2) DeZurik #118, F-RS24

F. Check Valves:

1. CK-1: 2" and under, 125# steam @ 406°F, 200# CWP @ 150°F, screwed, bronze, horizontal swing.

   a. Manufacturers:

      1) Crane #37
      2) Hammond #IB904
      3) Stockham #B319-Y
      4) Walworth #3406
      5) Milwaukee #509
      6) Watts #B-5000
      7) Nibco Y-413B

2. CK-13: 2-1/2" thru 12", 200# CWP, double disc wafer type, iron body, bronze or aluminum-bronze discs, 316SS shaft and spring, Viton, EPDM or BUNA-N, Cv of at least 700 in 6" size.

   a. Manufacturers:

      1) Mueller Steam Specialty Co. #71-AHB-6-H
      2) Stockham #WG-961 EPDM or #WG970 BUNA
      3) NIBCO W-920-W
      4) Crane

G. Strainers:

1. ST-2: Cast iron body, 125 lb. flanged ends, bolted cover, 125 psi S @ 350°F, 175 psi CWP @ 150°F.

   a. Manufacturers:

      1) Armstrong #A1FL
      2) Metraflex #TF
      3) Mueller Steam Specialty Co.#751
      4) Sarco #CI-125
      5) Watts #77F-D

2. ST-4: Cast iron body, screwed ends, screwed cover, 250# steam @ 406°F, 300# CWP @ 150°F.

   a. Manufacturers:

      1) Armstrong #A1SC
      2) Metraflex #SM

3) Mueller Steam Specialty Co. #11
4) Sarco #IT

2.2 STRAINERS

A. Unless otherwise indicated, strainers shall be Y-pattern and have stainless steel screens with perforations as follows:

1. Gases:

a. 1/4" - 2": 1/32" perforations
b. 2-1/2" - 10": 3/64" perforations
c. 12" - 18": 1/16" perforations

B. Furnish pipe nipple with shutoff valve to blow down all strainer screens.

C. Use iron body strainers in ferrous piping.

2.3 DRAIN VALVES AND BLOWDOWN VALVES

A. Drain valve and blowdown valve shall mean a shutoff valve as specified for the intended service with added 3/4" male hose thread outlet, cap, and retaining chain.

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. Remove all scale, rust, dirt, oils, stickers and thoroughly clean exterior of all bare metal exposed piping, hangers, and accessories in preparation to be painted.

D. Connect to all equipment with flanges or unions.

E. After completion, fill, clean, and treat systems. Refer to Section 23 25 00 for treatment.

3.2 TESTING PIPING

A. Low Pressure - Up to 1 psi:

1. Test piping with 20 psi air pressure. System must hold this pressure without adding air for two hours.

B. High Pressure - Above 1 psi:

1. Test piping with compressed air at twice the operating gas pressure, but at least 20 psi. System must hold this pressure without adding air for two hours.

C. A non-combustible odorant, such as oil of wintergreen, may be added to help locate leaks.

3.3 CLEANING PIPING

A. Assembly:

1. Prior to assembly of pipe and piping components, remove all loose dirt, scale, oil and other foreign matter on internal or external surfaces by means consistent with good piping practice subject to approval of the Architect/Engineer. Blow chips and burrs out of pipe before assembly. Wipe cutting oil from internal and external surfaces.
2. During fabrication and assembly, remove slag and weld spatter from both internal and external joints by peening, chipping and wire brushing to the degree consistent with good piping practices.
3. Notify the Architect/Engineer prior to starting any post erection cleaning operation in time to allow witnessing the operation. Properly dispose of cleaning and flushing fluids.
4. Prior to blowing or flushing erected piping systems, disconnect all instrumentation and equipment, open wide all valves, control valves, and balance valves, and verify all strainer screens are in place.

3.4 INSTALLATION

A. Route piping in orderly manner, straight, plumb, with consistent pitch, parallel to building structure, with minimum use of offsets and couplings. Provide only offsets required for needed headroom or clearance and needed flexibility in pipe system.

B. Install piping to conserve building space, and not interfere with other work.

C. Do not install piping or other equipment above electrical switchboards or panelboards. This includes a dedicated space extending 25 feet from the floor to the structural ceiling with width and depth equal to the equipment.

D. Group piping whenever practical at common elevations.

E. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.

F. Install thrust blocking and restraints on all buried piping at elbows and other changes in pipe direction.

G. Provide chain operators for all valves over 2" size that are over 10'-0" above finished floor. Extend to 7'-0" above finished floor.

H. Provide valve position indicator on all valves 10'-0" or greater above finish floor and not located above ceiling.

I. Provide clearance for access to valves and fittings.

J. Provide access doors where valves are not exposed.

K. Prepare pipe, fittings, supports, and accessories for finish painting.

L. Install valves with stems upright or horizontal, not inverted.

M. Provide shutoff valves and flanges or unions at all connections to equipment, traps, and items that require servicing.

N. Provide shutoff valves to isolate part of systems and vertical risers.

O. Provide shutoff valves to boilers and water heaters in readily accessible location, maximum 6 feet above finished floor, within 6 feet of boiler connection per ASME CSD-1.

P. Arrange piping and piping connections so equipment may be serviced or totally removed without disturbing piping beyond final connections and associated shutoff valves.

Q. Reducers are generally not shown. Where pipe sizes are not shown, the larger size in either direction shall continue through the fitting nearest to the indication of a smaller pipe size.

R. Lay all underground piping in trenches. Provide and operate pumping equipment to keep trenches free of water.

S. Seal pipes passing through exterior walls with a wall seal per Section 23 05 29. Provide Schedule 40 galvanized sleeve at least 2 pipe sizes larger than the pipe.

T. Refer to Section 23 05 00 for Excavation, Fill, Backfill and Compaction requirements.

U. All vertical pipe drops to equipment installed below the ceiling shall be routed within a wall cavity, unless specifically noted otherwise to be surface mounted. For renovation projects, this Contractor is responsible for opening and patching existing walls for installation of piping. Wall patching shall match existing condition.

V. Install underground plastic pipe with an electrically continuous corrosion-resistant tracer wire (minimum AWG 14) or tape per section 22 05 53 to facilitate locating. One end of the tracer wire or tape shall be brought aboveground at a building wall or riser.

W. Install corrugated, stainless steel tubing system according to manufacturer's written instructions. Include striker plates to protect tubing from puncture where tubing is restrained and cannot move.

X. Install underground, sleeved, corrugated, stainless steel tubing system according to manufacturer's written instructions. Extend vent from sleeve to exterior of building and terminate with screened elbow.

3.5 BONDING AND GROUNDING

A. Each above ground portion of a corrugated stainless steel tubing gas piping systems shall be bonded to the electrical service grounding electrode system. The bonding jumper shall connect to a metallic pipe or fitting between the point of delivery and the first downstream corrugated stainless steel tube fitting. The bonding jumper shall not be smaller than 6 AWG copper wire or equivalent. Gas piping systems that contain one or more segments of corrugated stainless steel tubing shall be bonded in accordance with this section.

B. Each above ground portion of a gas piping system, other than corrugated stainless steel tubing systems, that is likely to become energized shall be electrically continuous and bonded to an effective ground-fault current path. Gas piping, other than corrugated stainless steel tubing, shall be considered to be bonded when it is connected to appliances that are connected to the appliance grounding conductor of the circuit supplying that appliance.

C. Gas piping shall not be used as a grounding conductor or electrode.

D. Where a lightning protection system is installed, the bonding of the gas piping shall be in accordance with NFPA 780, Standard for the Installation of Lightning Protection Systems.

3.6 PIPE ERECTION AND LAYING

A. Carefully inspect all pipe, fittings, valves, equipment and accessories prior to installation. Immediately reject and remove from the job any items which are unsuitable, cracked or otherwise defective.

B. All pipe, fittings, valves, equipment and accessories shall have factory-applied markings, stampings, or nameplates sufficient to determine their conformance with specified requirements.

C. Exercise care at every stage of storage, handling, laying and erecting to prevent entry of foreign matter into piping, fittings, valves, equipment and accessories. Do not erect or install any unclean item.

D. During construction, until system is fully operational, keep all openings in piping and equipment closed at all times except when actual work is being performed on that item. Closures shall be plugs, caps, blind flanges or other items designed for this purpose.

E. Change direction of pipes only with fittings or pipe bends. Change size only with fittings. Do not use miter fittings, face or flush bushings, or street elbows. All fittings shall be long radius type, unless otherwise shown on the drawings or specified. Construct welded elbows of angles not available as standard fittings by cutting and welding standard elbows to form smooth, long radius fittings.

F. Use full and double lengths of pipe wherever possible.

G. Cut all pipe to exact measurement and install without springing or forcing.

H. Do not create, even temporarily, undue loads, forces or strains on valves, equipment or building elements.

I. Underground pipe shall be laid in dry trenches maintained free of accumulated water. Provide and operate sufficient pumping equipment to maintain excavations, trenches and pits free of water. Dispose of pumped water so operation areas and other facilities are not flooded. Pipe laying shall follow excavating as closely as possible.

3.7 DRAINING AND VENTING

A. Unless otherwise indicated on the drawings, all horizontal pipes, including branches, shall pitch 1" in 40 feet to low points for complete drainage.

B. Use eccentric reducing fittings on horizontal runs when changing size for proper drainage and venting. Install gas pipes with bottom of pipe and eccentric reducers in a continuous line.

C. Provide drip legs at low points and at the base of all risers in gas pipes. Drip legs shall be full line size on pipes through 4" and at least 4", but not less than half line size over 4". Drip legs shall be 12" minimum length, capped with a reducer to a drain valve.

3.8 BRANCH CONNECTIONS

A. Make branch connections with standard tee or cross fittings of the type required for the service unless otherwise specified herein or detailed on the drawings.

B. At the option of the Contractor, branch connections from headers and mains may be cut into black steel pipe using forged weld-on fittings.

C. Use of forged weld-on fittings is also limited as follows:

1. Must have at least same pressure rating as the main.
2. Header or main must be 2-1/2" or over.
3. Branch line is at least two pipe sizes under header or main size.

D. Reducers are generally not shown. Where pipe sizes change at tee, the tee shall be the size of the largest pipe shown connecting to it.

E. All branch piping connections for natural gas shall take off on the top or on the side of the main.

3.9 JOINING OF PIPE

A. Threaded Joints:

1. Ream pipe ends and remove all burrs and chips.

2. Protect plated pipe and valve bodies from wrench marks when making up joints.
3. Apply gas-rated Teflon tape or thread compound to male threads.

B. Flanged Joints:

1. Steel flanges shall be raised face.
2. Bolting for services up to 500°F shall be ASTM A307 Grade B with square head bolts and heavy hexagonal nuts conforming to ANSI B18.2.1 "Square and Hex Bolts" and B18.2.2 "Square and Hex Nuts".
3. Torque bolts in at least three passes, tightening to 1/3, 2/3, and final torque in a cross pattern with an indicating torque wrench for equal tension in all bolts.
4. Gaskets for flat face flanges shall be full face type. Gaskets for raised faced flanges shall conform to requirements for "Group I Gaskets" in ANSI B16.5. Unless otherwise specified gaskets shall meet the following requirements:

    a. Gasket material and thickness approved by manufacturer for intended service, chemical compatibility, pipe system test pressure, and operating temperature range.
    b. Maximum pressure rating of at least 250 psig.
    c. Minimum temperature rating: -10°F.
    d. Maximum temperature rating of at least 170°F for water systems operating 140°F and less.

C. Welded Joints:

1. Welding of all pipe joints, both as to procedures and qualification of welders, shall be in accordance with Section IX, ASME "Boiler & Pressure Vessel Code" unless local codes take precedence.
2. Furnish certificates qualifying each welder to the Owner's Representative prior to start of work.
3. The Owner's Representative reserves the right to require qualifying demonstration, at the Contractor's expense, of any welders assigned to the job.
4. Ends of pipe and fittings to be joined by butt-welding shall be beveled, cleaned to bare metal and internal diameters aligned before tack welding.

D. Fusion Weld:

1. Make all field cuts of pipe square and true using a pipe cutter designed for plastic pipe.
2. Make sure proper heating heads are used for male and female situations.
3. Bevel the leading edge of pipe section with a 45° chamfer.
4. Utilize a fusion welding tool recommended and/or provided by the pipe and fitting manufacturer.
5. Not recommended for temperatures below 40°F.
6. Follow the manufacturer's cold weather installation procedures.
7. All installers shall undergo training provided by the manufacturer or manufacturer's representative.
8. Follow all manufacturers' installation instructions.

3.10 PAINTING EXPOSED PIPE

A. Paint all outdoor exposed natural gas piping the color selected by Owner or Architect/Engineer.

3.11 SERVICE CONNECTIONS

A. Provide new gas service complete with gas meter and regulators. Verify gas service pressure with the Utility Company.

END OF SECTION 22 10 23

SECTION 22 10 30 - PLUMBING SPECIALTIES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Cleanouts.

B. Traps.

C. Trap Seals and Primers.

D. Floor Drains and Sinks

E. Hub Drains and Standpipes

F. Roof Drains.

G. Backflow Preventers.

H. Strainers.

I. Unions.

J. Balancing Valves.

K. Water Hammer Arresters.

L. Dielectric Fittings (Connections Between Dissimilar Metals).

M. Air Vents.

N. Drain Valves.

O. Relief Valves.

P. Compressed Air Filters.

Q. Compressed Air Condensate Traps.

1.2 QUALITY ASSURANCE

A. Manufacturer: For each product specified, provide components by same manufacturer throughout.

B. Piping, Fittings, Valves, and Flux for Potable Water Systems: All components shall be lead free per Federal Act S.3874, Reduction of Lead in Drinking Water Act.

1.3 SUBMITTALS

A. Submit shop drawings under provisions of Section 22 05 00.

B. Include sizes, rough-in requirements, service sizes, and finishes.

PART 2 - PRODUCTS

2.1 CLEANOUTS

A. Provide cleanouts as shown and specified on the drawings as well as required by code.

B. Coordinate floor cleanout cover with surrounding floor finish. Provide either solid, recessed for tile or terrazzo or carpet marker as applicable.

C. Cleanouts on exposed pipes shall be cast iron with heavy duty cast brass plug with raised head.

D. Cleanout shall be same size as the pipe up to 6" and 6" for larger pipes.

2.2 YARD CLEANOUTS

A. Provide yard cleanouts as shown and specified on the drawings as well as required by code.

B. Cleanout shall be same size as pipe up to 6" and 6" for larger pipes.

2.3 TRAPS

A. Provide all individual connections to the sanitary system with P-traps, except where such drains discharge directly into a properly trapped collection basin or sump. Unless otherwise specified or shown, traps shall be:

1. Chromium plated cast brass when used with plumbing fixtures or when installed exposed in finished spaces.
2. Insulated at accessible lavatories.
3. Cast iron, deep-seal pattern where concealed above ceiling, below grade or in unfinished areas.
4. Deep-seal pattern of the same material and/or coating where drainage lines are of special materials or coatings such as polypropylene, PVDF, CPVC, etc.

B. All traps shall have accessible, removable cleanouts, except where installed on floor drains with removable strainers.

C. Each trap shall be completely filled with water at the end of construction but before building turnover to the Owner. All floor drains, floor sinks, trench drains, etc. shall be filled with water and a 1/2" minimum layer of mineral oil.

2.4 TRAP SEALS AND PRIMERS

A. Provide trap seals as specified on the drawings.

B. Provide trap primers as shown and specified on the drawings.

2.5 FLOOR DRAINS AND SINKS

A. Floor drains and sinks shall be in the form of a receptor with grate/strainer set flush with the surrounding floor.

B. Provide floor drains and sinks as shown and specified on the drawings as well as required by code.

2.6 HUB DRAINS AND STANDPIPES

A. A hub drain shall be in the form of a hub or pipe without a grate/strainer extending through the floor for receiving indirect waste. A hub drain has a flood level rim above the finished floor.

B. Provide hub drains as shown and specified on the drawings as well as required by code.

2.7 ROOF DRAINS

A. Provide roof drains as shown and specified on the drawings as well as required by code.

2.8 BACKFLOW PREVENTERS

A. Provide backflow preventers as shown and specified on the drawings as well as required by code.

2.9 STRAINERS

A. Unless otherwise indicated, strainers shall be Y-pattern and have stainless steel screens with perforations as follows:

1. Air:

   a. 1/4" - 2": 1/32" perforations
   b. 2-1/2" - 10": 3/64" perforations
   c. 12" - 18": 1/16" perforations

2. Water:

   a. 1/4" - 2": 3/64" perforations
   b. 2-1/2" - 10": 1/16" perforations
   c. 12" - 18": 1/8" perforations

3. Lube, Hydraulic, No. 6 Fuel and Waste Oils:

   a. 1/4" - 2": 3/16" perforations
   b. 2-1/2" - 10": 3/16" perforations
   c. 12" - 18": 3/16" perforations

B. Furnish pipe nipple with shutoff valve to blow down all strainer screens.

C. Use bronze body strainers in copper piping and iron body strainers in ferrous piping.

D. All strainers to come with screw cap and chain attached to strainer body

2.10 UNIONS

A. Copper pipe - wrought copper fitting - ground joint.

B. Black Steel (Schedule 40) Pipe - malleable iron, ground joint, 150 psi, bronze to bronze seat.

C. Galvanized Steel Pipe - galvanized malleable iron, ground joint, 150 psi, bronze to bronze seat.

2.11 BALANCING VALVE

A. Rated for 125 psi working pressure and 250°F operating temperature, taps for determining flow with a portable meter, positive shutoff valves for each meter connection, memory feature, tight shutoff, and a permanent pressure drop between 1' and 2' water column at full flow with valve 100% open. Furnish with molded, removable insulation covers.

B. Provide a nomograph to determine flow from meter reading (and valve position on units which sense pressure across a valve). Graph shall extend below the specified minimum flow.

C. Furnish one meter kit equivalent to Bell & Gossett Model RO-5 meeting the following requirements:

1. Carrying case with handle.
2. Pressure gauge with 0-25 feet of head scale with 3.0% full scale accuracy.
3. High and low side hoses with 5 feet length and 250 psig pressure rating, equipped with shutoff valves, vent valves, and probes for insertion into pressure and temperature plugs.
4. Coordinate with the Mechanical Contractor if a meter kit is also required in Section 23 21 00. It is not our intent to require two identical kits, rather it will be acceptable to provide only one kit to the owner which can be used with both plumbing and hydronic piping systems.

D. Flow rate of 0.5 GPM or larger: Valves in copper piping shall be brass or bronze. Acceptable Manufacturers: Flow Design "Accusetter", Preso "B+", Armstrong "CVB", Bell & Gossett "Circuit Setter Plus", Griswold "Quickset", Gerand "Balvalve Venturi" or Nibco Globe Style balancing valve.

E. Flow rate less than 0.5 GPM: Valves in copper piping shall be brass or bronze. Cv value shall be less than 1.0 when valve is completely open, and minimum balanceable flow rate shall not exceed 0.1 GPM with a meter reading of at least 2.5 feet. Acceptable manufacturers: Bell & Gossett "Circuit Setter RF", Flow Design, Preso, Armstrong, Griswold, Gerand, or Nibco balancing valve.

F. Manufacturer shall size balancing valves for the scheduled flow rate. Flow rate shall be measurable on manufacturer's standard meters.

2.12 BALANCING VALVE WITH FLOW INDICATION

A. Balancing valve with built-in visual flow meter, adjustable flow control with memory stop feature, external temperature gauge, and tight shutoff.

B. Maximum working pressure: 150 psi. Maximum Temperature 230°F. Maximum differential pressure: 15 psi. Maximum inlet temperature: 195°F.

C. Low-lead brass valve, stainless steel springs, EPDM seals.

D. Manufacturer shall size balancing valves for the scheduled flow rate. Flow rate shall be measurable on the self-contained visual flow meter.

E. Acceptable Manufacturers:

1. Calieffi 132 Series
2. Watts CSD (provide with separate external temperature gauge)

2.13 WATER HAMMER ARRESTERS

A. Provide water hammer arresters as shown and specified on the drawings as well as required by code.

B. ANSI A112.26.1; sized and located in accordance with PDI WH-201, precharged for operation between -100°F and 300°F and maximum 250 psig working pressure.

2.14 DIELECTRIC FITTINGS (CONNECTIONS BETWEEN DISSIMILAR METALS)

A. Connections between dissimilar metals shall be insulating dielectric types that provide a water gap between the connected metals, and that either allow no metal path for electron transfer or that provide a wide water gap lined with a non-conductive material to impede electron transfer through the water path.

B. Joints shall be rated for the temperature, pressure, and other characteristics of the service in which they are used, including testing procedure.

C. Aluminum, iron, steel, brass, copper, bronze, and stainless steel are commonly used and require isolation from each other with the following exceptions:

1. Iron, steel, and stainless steel connected to each other.
2. Brass, copper, and bronze connected to each other.
3. Brass or bronze valves and specialties connected in closed systems with steel, iron, or stainless steel on both sides of the brass or bronze valves and specialties. Where two or more brass or bronze items occur together, they shall be connected with brass nipples. Brass or bronze valves and specialties cannot be used as a dielectric separation between pipe materials.

D. Dielectric protection is required at connections to equipment of a material different than the piping.

E. Screwed Joints (acceptable up to 2" size):

1. Dielectric waterway rated for 300 psi CWP and 225°F.
2. Acceptable Manufacturers: Elster Group ClearFlow fittings, Victaulic Series 47, Grinnell Series 407, Matco-Norca.

F. Flanged Joints (any size):

1. Use 1/8" minimum thickness, non-conductive, full-face gaskets.
2. Employ one-piece molded sleeve-washer combinations to break the electrical path through the bolts.
3. Sleeve-washers are required on one side only, with sleeves minimum 1/32" thick and washers minimum 1/8" thick.
4. Install steel washers on both sides of flanges to prevent damage to the sleeve-washer.
5. Separate sleeves and washers may be used only if the sleeves are manufactured to exact lengths and installed carefully so the sleeves must extend partially past each steel washer when tightened.
6. Acceptable Manufacturers: EPCO, Central Plastics, Pipeline Seal and Insulator, F. H. Maloney, or Calpico.

2.15 AIR VENTS

A. Provide means for venting air at all high points in the piping system and at all other points where air may be trapped.

B. At end of main and other points where large volume of air may be trapped - Use 1/4" globe valve, angle type, 125 psi, Crane #89, attached to coupling in top of main, 1/4" discharge pipe turned down with cap.

2.16 DRAIN VALVES

A. Drain valves shall be shutoff valves as specified for the intended service with added 3/4" male hose thread outlet and cap.

2.17 RELIEF VALVES

A. RV-3: (Compressed Air) Spring loaded disc type, cast iron or steel body, stainless steel disc, side outlet and lifting lever, 250# CWP. Acceptable Manufacturers: Consolidated Div. of Dresser Ind. Series 1900, Kunkle #463, Keckley Type 41.

B. RV-4: (Domestic Hot Water) Pressure and Temperature relief, cast bronze body and internal parts, stainless steel spring, test lever, threaded inlet and outlet. Maximum setting of 150 psi and 210°F temperature. Capacities ASME certified and labeled. Acceptable Manufacturers: Cash Series FV, Watts #40, #120, #N240, #340.

2.18 COMPRESSED AIR FILTERS

A. Filters shall have a stainless steel sleeve, micro-glass media with epoxy coating, elastomeric filter to housing seal and sealed end caps.

B. Filters shall be capable of removing the following:

1. All solids 3 microns and larger.
2. Liquids up to 25,000 ppm by weight.
3. 99% of water droplets.
4. 40% of oil aerosols.

C. Provide a differential pressure alarm for each filter. Range shall be adjustable from 10 to 35 psi differential at 100 psig.

D. Acceptable Manufacturer: Hankison.

2.19 COMPRESSED AIR CONDENSATE TRAPS

A. Furnish and install traps of the type and capacity shown on the drawings.

B. Traps shall be mechanically actuated with stainless steel construction, and 10-300 psig working pressure.

C. Acceptable Manufacturer: Hankison Series 505.

PART 3 - EXECUTION

3.1 INSTALLATION AND APPLICATION

A. Coordinate construction to receive drains at required invert elevations.

B. Install all items per manufacturer's instructions.

C. Water Hammer Arresters:

1. Install water hammer arresters in accessible locations. Provide access doors as required. Coordinate type with Architect/Engineer/Owner.
2. Water hammer arrestors shall be installed in cold and hot water lines upstream of all plumbing fixtures or equipment, with a quick acting valve or multiple quick acting valves. Quick acting valves shall be defined as solenoid actuated valves, manual flush valves, sensor activated faucets and flush valves, squeeze handle spray faucets, and other similar type valves.
3. Install multiple water hammer arrestors in toilet group branch piping greater than 20 feet in developed length from the cold and hot water mains.

D. Cleanouts:
1. Provide cleanouts where shown on the drawings and as required by code, but in no case farther apart than 50 feet in pipe less than 6" size and 100 feet apart in 6" and larger pipes inside the building. Provide cleanouts at bases of all sanitary and storm risers as shown on the drawings and as required by code.
2. Extend cleanouts to the floor with long sweep elbows.
3. Install a full size, two-way cleanout within 5 feet of the foundation inside or outside of building.
4. Extend cleanouts to finished floor or wall surface. Lubricate threaded cleanout plugs with graphite and linseed oil. Ensure clearance at cleanouts for rodding of drainage system.
5. Wall cleanouts shall be installed above the flow line of the pipe they serve, but no less than 12" above the finished floor.

E. Yard Cleanouts:

1. Install cleanouts on maximum 90 foot centers (including riser) for pipes 8" and smaller.
2. Extend cleanout to grade. Encase cleanout in 5" thick concrete pad extending 6" beyond cleanout, set low enough not to interfere with lawn mowers.

F. Trap Seals and Primers:

1. Install trap primer on drains not receiving continuous discharge and subject to drying out.
2. Connect trap primer to an active water line 1-1/2" in size or less and which will produce a 3 PSI pressure drop upon fixture operation downstream of the trap primer.

G. Floor Drains and Floor Sinks:

1. Drains in upper floors shall have a flashing of EPDM or similar membrane sheet. The sheet shall be at least 36" X 36" square with the drain in the center. Clamp membrane in auxiliary clamping ring of floor drain. Membrane is not required if upper floor construction is single pour, cast-in-place concrete.
2. Use alternate sealing method when installing drains in existing floor slabs.
3. Coordinate sloping requirements with the architectural plans and specifications.
4. Top of floor drain and sinks grate/strainer shall not extend above the finished floor elevation.
5. Top of floor drain and sink grate/strainer shall not extend above the finished floor elevation. Grate/strainer shall be installed flush with surrounding finished floor. Should the Plumbing Contractor believe this presents a conflict with code, the issue should be evaluated before installation of the floor drain or sink begins. Proceeding with installing a floor drain or sink raised above the finished floor without prior approval will result in the Contractor being required to remove the drain or sink in question and reinstall it at the approved elevation.

H. Hub Drains and Standpipes:

1. The top of a hub drain/standpipe shall extend above the finished floor elevation. Refer to drawings for dimensions above the finished floor.
2. Access shall be provided to drains and standpipes for rodding.

I. Roof Drains:

1. Roof drains shall have bearing pans.
2. Provide auxiliary support steel under drains as required to prevent movement of the drain.
3. All roof drains shall have underdeck clamps.
4. Drains in built-up roofing systems shall have a 36" x 36", 3 lb density lead sheet flashing.

J. Backflow Preventer:

1. Provide an air gap fitting and piping to drain. On 2-1/2" and larger units, install a tail piece from air gap fitting to drain to prevent water from spraying out of drain air gap receptor. Maintain air gap distance required by Code.
2. Units shall be field tested and tagged in accordance with manufacturer's instructions and applicable codes by a certified tester before initial operation.

3. Install unit between 12" and 60" above finish floor.

K. Balancing Valves:

1. Install balancing valves with straight, unobstructed pipe section both upstream and downstream as required, per manufacturer's installation instructions.

END OF SECTION 22 10 30

SECTION 22 14 29 - SUMP PUMPS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Sump Pumps.

1.2 SUBMITTALS

A. Submit shop drawings under provisions of Section 22 05 00.

B. Submit certified pump performance curves with pump and system operating point plotted. Include NPSH curve when applicable.

C. Pumps with motors operating above the RPM the pump curves are based on shall have impellers trimmed to deliver GPM and head scheduled.

D. Submit electrical power/controls wiring diagrams and product data indicating general assembly, components, safety controls, and service connections.

E. Submit certification that pumps, accessories, and components will withstand seismic forces defined in Section 22 05 50. Include the following:

1. Basis for Certification: Indicate whether certification is based on actual test of assembled components or on calculation.

   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

F. Manufacturer shall provide special seismic certification per HCAI CAN 2-1708a.5 with submittal. Submittals without certification will be returned and not reviewed.

PART 2 - PRODUCTS

2.1 GENERAL

A. Statically and dynamically balance rotating parts.

B. Construction shall permit complete servicing without breaking piping or motor connections.

C. Pumps shall operate at 1750 rpm unless specified otherwise.

D. Pump connections shall be flanged, whenever available.

E. Motors shall comply with Section 22 05 13.

F. The discharge pipe sizes shall meet or exceed the scheduled pump.

2.2 SUMP PUMPS

A. Provide pumps as specified on the drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all products per manufacturer's recommendations.

B. Install pumps and arrange to provide access for maintenance including removal of motors, impellers, couplings and accessories.

C. Support piping so weight of piping is not supported by pumps.

D. Mount control panel on adjacent wall within required distance for cables and wiring. Provide unistrut mounting frame for the control panel if wall space is not available. Properly anchor frame to floor.

E. Ensure pumps operate at specified fluid temperatures without vapor binding or cavitation, are non-overloading in parallel or individual operation, and operate within 25% of midpoint of published maximum efficiency curve.

F. Pumps shall be factory aligned. If alignment is not satisfactory, as determined by the Architect/Engineer, manufacturer shall provide a factory trained representative to field align the shafts.

G. Sump pumps that discharge to storm shall be installed with the top of the sump basin 2" above floor level. A 2" high x 4" wide concrete curb around the perimeter of the basin lid may be used in lieu of raising the entire sump basin.

H. Set submersible sump pumps on basin/pit floor. Make direct connections to storm drainage piping.

I. Install sump pump basins and connect to drainage piping. Brace interior of basins according to manufacturer's written instructions to prevent distortion or collapse during concrete placement. Set basin cover and fasten to basin top flange. Install cover so top surface is flush with finished floor.

END OF SECTION 22 14 29

SECTION 22 15 19 - COMPRESSED AIR SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Compressed Air Piping (Non-Medical)

B. Condensate Piping

C. Shutoff Valves

D. Check Valves

E. Automatic Drain Valves

F. Safety Relief Valves

G. Strainers

H. Filter

I. Pressure Gauge

J. Flexible Connections

K. Hose Reels

L. Point-of-Use Couplings

M. Air Receiver

N. Lockout Trim

O. Valve Operators

P. Valve Connections

1.2 QUALITY ASSURANCE

A. Valves: Manufacturer's name and pressure rating marked on valve body. Remanufactured valves are <u>not</u> acceptable.

B. Welding Materials and Procedures: Conform to ASME Code and applicable state labor regulations.

C. Welders Certification: In accordance with ANSI/ASME Sec 9 or ANSI/AWS D1.1.

1.3 SUBMITTALS

A. Submit shop drawings per Section 22 05 00.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store valves in shipping containers with labeling in place.

1.5 COORDINATION DRAWINGS

A. Reference Coordination Drawings article in Section 22 05 00 for required plumbing systems electronic CAD drawings to be provided to Coordinating Contractor for inclusion into composite coordination drawings.

PART 2 - PRODUCTS

2.1 COMPRESSED AIR PIPING (NON-MEDICAL)

A. Design Pressure: 125 psi; Maximum Design Temperature: 150°F

B. Piping - 2" and Under:

1. Tubing: Type L hard drawn seamless copper tube, ASTM B88.
2. Joints: Solder with 100% lead-free solder and flux, ASTM B32.
3. Fittings: Wrought copper solder joint, ANSI B16.22.

2.2 CONDENSATE PIPING

A. Design Pressure: 125 psi; Maximum Design Temperature: 150°F

B. Piping - 2" and Under:

1. Tubing: Type DWV hard drawn seamless copper tube, ASTM B306.
2. Joints: Solder with 100% lead-free solder and flux, ASTM B32.
3. Fittings: Wrought copper solder joint, ANSI B16.22.

2.3 SHUTOFF VALVES

A. Ball Valves:

1. BA-1: 3" and under, 150 psi saturated steam, 600 psi CWP, full port, vented, screwed or solder ends (acceptable only if rated for soldering in line with 470°F melting point of lead-free solder), bronze body of a copper alloy containing less than 15% zinc, stainless steel ball and trim, Teflon seats and seals.

a. Manufacturers:

1) Apollo #77C-140
2) Stockham #S-255-FB-P-UL
3) Milwaukee #BA-400
4) Watts
5) Nibco #585-70-66
6) National Utilities Co.
7) RUB

b. NOTES: Provide lockout trim for all valves.

2.4 CHECK VALVES

A. CK-5: 2" and under, 250# CWP, screwed, all iron, horizontal swing.

1. Manufacturers:

a. Crane #346-1/2

B. CK-20: 2" and larger, 125# CWP, flanged, iron body, cast iron or carbon steel body with stainless steel internals.

1. Manufacturers:

a. Hoerbiger Design "CT"

1) NOTE: Use only for compressor discharge.

2.5 AUTOMATIC DRAIN VALVES

A. Zero Loss Drain:

1. Electronic Operation: Electronic level control to monitor liquid level in the drain. Electronic control opens drain valve to discharge condensate and closes before compressed air is lost. 120VAC, alarm mode with visual signal and potential-free contact.

a. Manufacturers:

1) Gardner Denver EEDS series
2) Parker Finite series
3) Ingersoll-Rand ENL series
4) Quincy Q-MAT series

2. Float Operation: Discharge of condensate with float operation, on-demand operation.

a. Manufacturers:

1) Gardner Denver DS1 series
2) SMC AD402-A series

2.6 SAFETY RELIEF VALVES

A. Bronze body, test lever, metal seat, bronze disc, ASME Section VIII Air/Gas code stamped, factory set pressure as scheduled.

1. Manufacturers:

a. Kunkle Series 6000
b. Approved equal

2.7 STRAINERS

A. ST-2: Cast iron body, 125 lb. flanged ends, bolted cover, 125 psi steam @ 350°F, 175 psi CWP @ 150°F.

1. Manufacturers:

   a. Armstrong #A1FL
   b. Metraflex #TF
   c. Mueller Steam Specialty Co.#751
   d. Sarco #CI-125
   e. Watts #77F-D

B. ST-4: Cast iron body, screwed ends, screwed cover, 250# steam @ 406°F, 300# CWP @ 150°F.

1. Manufacturers:

   a. Armstrong #A1SC
   b. Metraflex #SM
   c. Mueller Steam Specialty Co. #11
   d. Sarco #IT

2.8 PRESSURE GAUGE

A. Accuracy Grade 1A (+/- 1% full range), dry for air service, with stainless steel or brass case, non-shatterable safety glass, pressure blowout back, 3-1/2" minimum diameter dial, dial range 0 psi to 200 psi, ASME B40.100 compliant.

1. Manufacturer:

   a. Ashcroft 1009

2.9 PRESSURE FLOW CONTROLLER

A. Flow controller shall provide consistent line pressure +/-1% of setpoint while adjusting airflow to meet demand.

B. Inlet pressure range 50 psi to 250psi, setpoint pressure range 40 psi to 225 psi, maximum pressure rating 200 psi, maximum operating temperature 150°F

C. Approved Manufacturers:

1. Quincy
2. Gardner Denver
3. Ingersoll-Rand
4. Kaeser

2.10 FLEXIBLE CONNECTIONS

A. Vibration isolation, wire braid reinforced corrugated metal hose type, line-sized, with bronze end connections, suitable for pressure indicated, length as recommended by manufacturer not less than 18".

B. Hose whip, rubber hose, line size, minimum 250 psi working pressure rating, brass crimped NPT fittings, 36" maximum length.

2.11 HOSE REELS

A. Steel heavy duty construction, open type, spring return, 4-way hose rollers, 3/8" x 50' rubber hose, adjustable hose stop, 250 psi minimum rating, adjustable guide arm for multiple mounting positions.

1. Manufacturers:

   a. Reelcraft 7000 & HD70000 series
   b. Coxreels SH series
   c. Hannay N700 series

2.12 POINT-OF-USE COUPLINGS

A. Non-exhausting Type: All brass construction, 1/4" body size, 125 psi minimum working pressure rating, general purpose, manual connect, industrial interchange style, coupling shall have female NPT connection with automatic shutoff, plug shall have male NPT connection.

   1. Manufacturers:

      a. Milton, Parker 20 Series
      b. Approved equal

B. Exhausting Type: All brass construction, 1/4" body size, 125 psi minimum working pressure rating, general purpose, push-to-connect, industrial interchange style, coupling shall have female NPT connection with automatic shutoff, plug shall have male NPT connection and ball check to bleed pressure from hose.

   1. Manufacturers:

      a. Parker E-z-mate series

2.13 LOCKOUT TRIM

A. Provide lockout trim for all quarter turn shutoff valves.

2.14 VALVE OPERATORS

A. Provide handwheels for gate valves and gear operators for butterfly valves.

2.15 VALVE CONNECTIONS

A. Provide all connections to match pipe joints. Valves shall be same size as pipe unless noted otherwise.

PART 3 - EXECUTION

3.1 PREPARATION

A. Install all products per manufacturer's recommendations.

B. Ream pipe and tube ends. Remove burrs. Bevel plain end ferrous pipe.

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

D. Connect to equipment with flanges or unions.

3.2 TESTING PIPING

A. Compressed Air Piping, Condensate Piping:

1. Test piping using compressed air per ASME 31.9 requirements.
2. Test piping at 125% of normal operating pressure in accordance with ASME 31.9.
3. Piping shall hold this pressure for one hour with no drop in pressure.

3.3 CLEANING PIPING

A. Assembly:

1. Before assembling pipe systems, remove all loose dirt, scale, oil and other foreign matter on internal or external surfaces by means consistent with good piping practice subject to approval of the Architect/Engineer's representative. Blow chips and burrs from machinery or thread cutting operation out of pipe before assembly. Wipe cutting oil from internal and external surfaces.
2. During fabrication and assembly, remove slag and weld spatter from both internal and external joints by peening, chipping and wire brushing.
3. Notify the Architect/Engineer's representative before starting any post erection cleaning in sufficient time to allow witnessing the operation. Consult with and obtain approval from the Architect/Engineer's representative regarding specific procedures and scheduling. Dispose of cleaning and flushing fluids properly.
4. Prior to blowing or flushing erected piping systems, disconnect all instrumentation and equipment, open wide all valves, and be certain all strainer screens are in place.

B. Air Blow:

1. Blow out pipe and components with clean compressed air. Instrument air lines shall be blown out with dry, oil free air or nitrogen gas. "Oil Free" is defined as air compressed in a centrifugal, Teflon ring, carbon ring or water pumped air compressor. Where air supply is judged to be inadequate to continually attain cleaning velocity, alternate pressurization and sudden relief procedure may be used until discharge at all blowout points is clean. Use 80-90 psig pressure unless otherwise indicated.

3.4 INSTALLATION

A. General Installation Requirements:

1. Provide dielectric connections between dissimilar metals.
2. Route piping in orderly manner and maintain gradient. Install to conserve building space.
3. Group piping whenever practical at common elevations.
4. Install piping to allow for expansion and contraction without stressing pipe, joints, or equipment.
5. Where pipe supports are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welds.
6. Seal pipes passing through exterior walls with a wall seal per Section 22 05 29. Provide Schedule 40 galvanized sleeve at least 2 pipe sizes larger than the pipe.

B. Installation Requirements In Electrical Rooms:

1. Do not install piping or other equipment above electrical switchboards or panelboards. This includes a dedicated space extending 25 feet from the floor to the structural ceiling with width and depth equal to the equipment.

C. Valves/Fittings and Accessories:

1. Install shutoff valves that permit the isolation of each equipment connection without isolating any equipment or portion of the system, unless noted otherwise.
2. Provide clearance for installation of insulation and access to valves and fittings.

3. Provide access doors for concealed valves and fittings.
4. Install valve stems upright or horizontal, not inverted.

3.5 PIPE ERECTION AND LAYING

A. Carefully inspect all pipe, fittings, valves, equipment and accessories before installation. Any items that are unsuitable, cracked or otherwise defective shall be removed from the job immediately.

B. All pipe, fittings, valves, equipment and accessories shall have factory applied markings, stampings, or nameplates with sufficient data to determine their conformance with specified requirements.

C. Exercise care at every stage of storage, handling, laying and erecting to prevent entry of foreign matter into piping, fittings, valves, equipment and accessories. Do not install any item that is not clean.

D. Until system is fully operational, all openings in piping and equipment shall be kept closed except when actual work is being performed on that item or system. Closures shall be plugs, caps, blind flanges or other items specifically designed and intended for this purpose.

E. Run pipes straight and true, parallel to building lines with minimum use of offsets and couplings. Provide only offsets required to provide needed headroom or clearance and to provide needed flexibility in pipe lines.

F. Make changes in direction of pipes only with fittings. Changes in size only with fittings. Do not use miter fittings, face or flush bushings, or street elbows. All fittings shall be of the long radius type, unless otherwise shown on the drawings or specified.

G. Provide flanges or unions at all final connections to equipment, traps and valves.

H. Arrange piping and connections so equipment served may be totally removed without disturbing piping beyond final connections and associated shutoff valves.

I. Use full and double lengths of pipe wherever possible.

J. Unless otherwise indicated, install all piping, including shutoff valves, filters, and regulators, to equipment at line size with reduction in size being made only at control valve or equipment.

K. Cut all pipe to exact measurement and install without springing or forcing except in the case of expansion loops where cold springing is indicated on the drawings.

L. Unless otherwise indicated, branch take-offs shall be from top of mains or headers at either a 45° or 90° angle from the horizontal plane to prevent carryover of condensate and foreign matter.

3.6 DRAINING AND VENTING

A. Unless otherwise indicated on the drawings, all condensate and compressed air lines, including branches, shall pitch 1" in 40 feet in the direction of airflow to low points for complete drainage, removal of condensate.

B. Maintain accurate grade where pipes pitch or slope for venting and drainage. No pipes shall have pockets due to changes in elevation.

C. Provide drip legs at low points and at the base of all risers in compressed air pipes. Drip legs shall be full line size on pipes through 4" and at least 4", but not less than half line size over 4". Drip legs shall be 12" minimum length, capped with a reducer to a drain valve.

D. Use eccentric reducing fittings on horizontal runs when changing size of pipes for proper drainage and venting. Install compressed air and gravity drain pipes with bottom of pipe and eccentric reducers in a continuous line; all other liquid lines with top of pipe and eccentric reducers in a continuous line.

E. Provide air vents at high points and wherever else required to eliminate air in all condensate piping systems.

3.7 BRANCH CONNECTIONS

A. Reducers are generally not shown. Where pipe sizes change at tee, the tee shall be the size of the largest pipe shown connecting to it.

B. Do not use double wye or double combination wye and eighth bend DWV fittings in horizontal piping.

C. Branch connections from headers and mains may be cut into black steel pipe using forged weld-on fittings.

D. Forged weld-on fittings are limited as follows:

1. Must have at least same pressure rating as the main.
2. Main must be 2-1/2" or larger.
3. Branch line is at least two pipe sizes under main size.

3.8 JOINING OF PIPE

A. Threaded Joints:

1. Threads shall conform to ANSI B2.1 "Pipe Threads".
2. Ream pipe ends and remove all burrs and chips formed in cutting and threading.
3. Protect plated pipe and valve bodies from wrench marks when making up joints.
4. Apply PTFE thread lubricant to male threads

B. Flanged Joints:

1. Steel pipe flanges shall conform to ANSI B16.5 "Steel Pipe Flanges and Flanged Fittings". Cast iron pipe flanges shall conform to ANSI B16.1 "Cast Iron Flanged and Flanged Fittings". Steel flanges shall be raised face except when bolted to flat face cast iron flange.
2. Bolting for services up to 500°F shall be ASTM A307 Grade B with square head bolts and heavy hexagonal nuts conforming to ANSI B18.2.1 "Square and Hex Bolts" and B18.2.2 "Square and Hex Nuts".
3. Set flange bolts beyond finger tightness with a torque wrench for equal tension in all bolts. Tighten bolts so those 180° apart are torqued in sequence.
4. Gaskets for flat face flanges shall be full face type. Gaskets for raised faced flanges shall conform to requirements for "Group I Gaskets" in ANSI B16.5. Unless otherwise specified gaskets shall meet the following requirements:

   a. Gasket material and thickness approved by manufacturer for intended service, chemical compatibility, pipe system test pressure, and operating temperature range.
   b. Maximum pressure rating of at least 250 psig.
   c. Minimum temperature rating: -10°F.
   d. Maximum temperature rating of at least 170°F.

C. Solder Joints:

1. Make up joints with 100% lead-free solder, ASTM B32. Cut tubing so ends are perfectly square and remove all burrs inside and outside. Thoroughly clean sockets of fittings and ends of tubing to remove all oxide, dirt and grease just prior to soldering. Apply flux evenly, but sparingly, over all surfaces to be joined. Heat joints uniformly so solder will flow to all mated surfaces. Wipe excess solder, leaving a uniform fillet around cup of fitting.
2. Flux shall be non-acid type.
3. Solder end valves may be installed directly in the piping system if the entire valve is suitable for use with 470°F melting point solder. Remove discs and seals during soldering if they are not suitable for 470°F.

END OF SECTION 22 15 19

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SECTION 22 40 00 - PLUMBING FIXTURES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. All plumbing fixtures.

1.2 SUBMITTALS

A. Submit product data under provisions of Section 22 05 00. Submittals shall include fixture carriers for record purposes only. Architect/Engineer does not review or approve carriers except for manufacturer.

B. Include fixtures, sizes, rough-in dimensions, utility sizes, trim, and finishes.

C. For fixtures and trim requiring electrical connections, submit product data indicating general assembly, components, electrical power/controls wiring diagrams, and service connections.

PART 2 - PRODUCTS

2.1 DSA FIXTURE REQUIREMENT

A. Plumbing fixtures and accessories provided in a toilet room or bathing room are required to comply with CBC Section 11B-213.2 and shall comply with CBC Section 11B-213.3.

B. Effective March 1, 2017, all single-user toilet facilities shall be identified as Gender-Neutral facilities by a door symbol that complies with CBC Sections 11B-216.8 and 11B-703.2.6.3. No pictogram, text, or braille is required on the symbol. If tactile jamb signage is provided, the signage shall comply with the appropriate technical requirements of CBC Section 11B-703. Examples of appropriate designations are "ALL-GENDER RESTROOM", "RESTROOM" or "UNISEX RESTROOM". DSA BU 17-01.

C. Accessible plumbing fixtures shall comply with all the requirements in CBC Division 6.

D. Clearance around accessible water closets and in toilet compartments shall be 60 inches minimum measured perpendicular from the side wall and 56 inches minimum measured perpendicular from the rear wall per CBC Section 11B-604.4.1.

E. Heights and location of all accessible fixtures shall be mounted according to CBC Sections 11B-602 through 11B-612.

F. Fixture controls shall comply with CBC Sections 11B-601.3 for drinking fountains, 11B-604.6 for water closets, 11B-604.9.5 for children's water closets, 11B-605.4 for urinals, 11B-606.4 for lavatories and sinks, 11B-607.5 for bathtubs, 11B-608.5 for showers, and 11B-611.3 for washing machines and clothes dryers.

G. Accessible sinks shall be 6-1/2” deep maximum. Sinks shall be mounted with the front of the higher of the rim and counter surface 34” maximum above the finish floor or ground.

H. Water supply and drain pipes under lavatories and sinks shall be insulated or otherwise configured to protect against contact. There shall be no sharp or abrasive surfaces under lavatories and sinks. CBC Section 11B-606.

2.2 MATERIALS

A. Wall Hung Fixture Carriers:

1. Material: All Metal, ASME/ANSI A112.6.1M.
2. Manufacturers:

   a. Zurn
   b. Smith
   c. Wade
   d. Josam
   e. Watts
   f. Mifab.

3. Water closet carrier shall be rated to support 500 lbs. unless noted otherwise on the drawings.

B. All fixtures shall be as scheduled on the drawings.

C. All china shall be from the same manufacturer where possible.

D. All lavatory and sink trim shall be from the same manufacturer where possible.

E. All fixtures shall be lead free. Faucets, traps, stops, and other fixture accessories shall not contain more lead than allowed per the latest State or Federal Act.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General Installation Requirements:

1. Review millwork shop drawings. Confirm location and size of fixtures and openings before rough-in and installation.
2. Install each fixture with trap easily removable for servicing and cleaning. Use screwed tailpiece couplings. Connect fixture waste to stack with slip fitting.
3. Provide fixtures with chrome plated rigid or flexible supplies, loose key stops, reducers, and escutcheons.
4. Install components level and plumb.
5. Caulk joint between finish floor and floor mounted fixtures and between finish walls and wall mounted fixtures with silicon caulk. Caulk the joint, between rim and fixture where a fixture builds into a countertop, with caulking compound. Refer to DIVISION 7 for "Caulking" requirements. Color to match fixture.
6. Where there is a possibility of water following pipe brackets, etc., into a wall; caulk escutcheons, space around brackets, etc., to exclude water. Refer to DIVISION 7 for "Caulking" requirements.
7. Refer to architectural drawings for fixture mounting heights.
8. All non-potable outlets shall be clearly marked with a permanently affixed laminated sign with 3/8" high lettering saying "Non-Potable Water Not for Human Consumption." Sign shall have black lettering on a yellow background.

B. Wall-Mounted Fixture Requirements:

1. All wall-mounted fixtures shall have compatible carriers designed for their intended service and suitable for the space available and configuration of fixtures. All carriers shall extend to the floor and be anchored to the slab.

C. Floor-Mounted Fixture Requirements:

1. Where floor mounted fixtures are installed on a sloped floor, the open void below the fixture shall be grouted, leveled, and caulked to eliminate stress on the fixture and to prevent water migration to the floor below.

D. Exposed or Inside Accessible Cabinets Traps, Valve and Pipe Requirements:

1. All traps exposed under fixtures or inside accessible cabinets shall be chrome plated brass.
2. All water or waste piping for plumbing fixtures that is exposed or inside cabinets shall be chrome plated.
3. All exposed flush valves for water closets and urinals shall have a chrome plated hanger to anchor the piping to the wall.
4. All exposed water supply piping and fittings in a finished space to a shower valve, hose bibb, or other water outlet shall be chrome plated.

E. ADA Accessible Exposed Sink and Lavatory Trim:

1. All exposed sink and lavatory traps, piping and angle stops installed at accessible sink and lavatory locations shall include offset style drain tailpiece, p-trap installed near and parallel with back wall, and insulation kit specially manufactured for this installation. Armaflex with duct tape is not acceptable.

F. ADA Accessible Water Closet Requirements:

1. Handicapped accessible water closet flush valve handles shall face the center of the stall.
2. Coordinate flush valves in handicap accessible locations with grab bars installed by the General Contractor. Make modifications as necessary to flush valve piping to avoid conflict with grab bars. Common solutions include shortened or offset vacuum breaker tailpieces.

3.2 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, equipment, and faucet aerator screens.

3.3 FIXTURE ROUGH-IN SCHEDULE

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

END OF SECTION 22 40 00

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SECTION 22 67 00 - PLUMBING PURE WATER PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Type II Water

B. Pipe and Pipe Fittings

C. Valves

1.2 QUALITY ASSURANCE

A. Valves: Manufacturer's name and pressure rating marked on valve body. Remanufactured valves are not acceptable.

1.3 SUBMITTALS

A. Submit shop drawings under provisions of Section 22 05 00. Include manufacturer's installation instructions.

B. For domestic hot water storage tanks, include tank lining instructions.

C. Include dimensions of tanks, anchors, attachments, lifting points, tappings, and drains.

D. For equipment connected to an electric power source, submit short circuit rating (SCCR) of integrated unit.

E. Submit manufacturer's installation instructions including control and electrical power/controls wiring diagrams.

F. Submit operation, maintenance, and inspection data, replacement part numbers and availability, and service depot location and telephone number.

G. Submit a current water analysis from the actual water source serving the project site existing building for softening equipment verification before sending shop drawings to the Architect/Engineer.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store valves in shipping containers with labeling in place.

1.5 COORDINATION DRAWINGS

A. Reference Coordination Drawings article in Section 22 05 00 for required plumbing systems electronic CAD drawings to be provided by Culligan Water to the Coordinating Contractor for inclusion into composite coordination drawings.

PART 2 - PRODUCTS

2.1 TYPE II WATER

A. Research Lab Standards:

1. Electrical Resistivity: 5 Mega-ohm @ 77°F
2. Total Organic Carbon: Less than 30 PPM

B. ASTM Standards:

1. Electrical Resistivity: 1 mega-ohm @ 77°F
2. Total Organic Carbon: 50 PPB

2.2 TYPE I ULTRA-PURE AND TYPE II PURE WATER - PIPING

A. Design Pressure: 150 psi at 70°F

B. Piping:

1. Pipe: Schedule 80 polypropylene UV Resistant Piping without plasticizers or pigments, ASTM D-1785.
2. Joints: Fused type.
3. Fittings: Polypropylene socket fused or flanged fittings, ASTM D-4101.
4. Products: All manufacturers must have approval to furnish this system. Purity test data and fitting samples are required for evaluation of equivalency.
5. Limitations: Not for use in return air plenums unless externally wrapped with plenum rated insulation.

C. Acceptable products are as follows: Georg Fischer -PROGEF Standard, Enfield, Nibco/Chemtrol, Orion Pure Water Piping.

1. Quality Assurance: All pipe and fittings shall have their ends bagged and sealed or plugged from the time of manufacture until just prior to joining. Open-end pipe is not permitted on the job site. This applies both before and after installation. If, in the Owner's opinion, insufficient care has been taken to keep the pipe interior clean, the Contractor shall perform the cleaning procedure twice at Contractor's cost, draining between sterilizations.
2. Any equipment required for installation of the piping shall be purchased by the contractor. At the end of construction, equipment will be turned back over to manfuacturer to be recalibrated and renewed prior to being returned to owner for future maintenance.
3. All installers and maintenance staff to go through manufacturers training prior to install or maintenance.

D. Piping:

1. Pipe: Schedule 80 polyvinylidene fluoride PVDF from virgin, unpigmented resin meeting ASTM D3222. Pipe will meet all dimensional tolerances of ASTM D2447.
2. Joints: Fused type.
3. Fittings: Polyvinylidene fluoride PVDF, Schedule 80, socket fused fittings, ASTM 2657.
4. Limitations: Allowable for use in return air plenums.

E. Acceptable products are as follows: George Fischer SYGEF, IPEX Plenumline, Nibco/Chemtrol, Simtech, Orion.

1. Quality Assurance: All pipe and fittings shall have their ends bagged and sealed or plugged from the time of manufacture until just prior to joining. Open-end pipe is not permitted on the job site. This applies both before and after installation. If, in the Owner's opinion, insufficient care has been taken to keep the pipe interior clean, the Contractor shall perform the cleaning procedure twice at Contractor's cost, draining between sterilizations.

F. Valves:

1. Unless noted otherwise, valves shall be diaphragm valves.
2. All valves shall be purchased as a complete system by piping manufacturer.

PART 3 - EXECUTION

3.1 PREPARATION

A. Install all products per manufacturer's recommendations.

B. Ream pipe and tube ends. Remove burrs.

C. Remove scale and dirt, on inside and outside, before assembly.

D. Remove all scale, rust, dirt, oils, stickers and thoroughly clean exterior of all bare metal exposed piping, hangers, and accessories in preparation to be painted.

E. Connect to equipment with flanges or unions.

3.2 TESTING PIPING

A. Test piping at 150% of normal operating pressure.

B. Piping shall hold this pressure for one hour with no drop in pressure.

C. Test piping using water, nitrogen, or air as compatible with the final service of the pipe. Do not use combustible fluids.

D. Drain and clean all piping after testing is complete.

3.3 CLEANING PIPING

A. Assembly:

1. Before assembling pipe systems, remove all loose dirt, scale, oil and other foreign matter on internal or external surfaces by means consistent with good piping practice subject to approval of the Architect/Engineer's representative.
2. Notify the Architect/Engineer's representative before starting any post erection cleaning in sufficient time to allow witnessing the operation. Consult with and obtain approval from the Architect/Engineer's representative regarding specific procedures and scheduling. Dispose of cleaning and flushing fluids properly.
3. Prior to flushing erected piping systems, disconnect all instrumentation and equipment, open wide all valves, and be certain all strainer screens are in place.

B. Cleaning Piping:

1. Clean as required by Pure Water Equipment Vendor to maintain required water quality.

3.4 INSTALLATION

A. General Installation Requirements:

1. Install all items in accordance with manufacturer's instructions.
2. Route piping in orderly manner and maintain gradient. Install to conserve building space.
3. Group piping whenever practical at common elevations.
4. Install piping to allow for expansion and contraction without stressing pipe, joints, or equipment.
5. Slope water piping and arrange to drain at low points.
6. Where pipe supports are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welds.
7. Seal pipes passing through exterior walls with a wall seal per Section 22 05 29. Provide Schedule 40 galvanized sleeve at least 2 pipe sizes larger than the pipe.
8. All outlets shall be clearly marked with a permanently affixed laminated sign with 3/8" high lettering saying "Pure Water, Not for Human Consumption." Sign shall have black lettering on a yellow background.
9. All vertical pipe drops to sinks or other equipment installed below the ceiling shall be routed within a wall cavity, unless specifically noted otherwise to be surface mounted. For renovation projects, this Contractor is responsible for opening and patching existing walls for installation of piping. Wall patching shall match existing condition.

B. Installation Requirements In Electrical Rooms:

1. Do not install piping or other equipment above electrical switchboards or panelboards. This includes a dedicated space extending 25 feet from the floor to the structural ceiling with width and depth equal to the equipment.

C. Valves/Fittings and Accessories:

1. Provide clearance for installation of insulation and access to valves and fittings.
2. Provide access doors for concealed valves and fittings.
3. Install valve stems upright or horizontal, not inverted.

D. Tanks:

1. Support indoor tanks from building structure or construct support stand.
2. Provide all flexible connections required due to tank flex during fill operation.

3.5 PIPE ERECTION AND LAYING

A. Carefully inspect all pipe, fittings, valves, equipment and accessories before installation. Any items that are unsuitable, cracked or otherwise defective shall be removed from the job immediately.

B. All pipe, fittings, valves, equipment and accessories shall have factory applied markings, stampings, or nameplates with sufficient data to determine their conformance with specified requirements.

C. Exercise care at every stage of storage, handling, laying and erecting to prevent entry of foreign matter into piping, fittings, valves, equipment and accessories. Do not install any item that is not clean.

D. Until system is fully operational, all openings in piping and equipment shall be kept closed except when actual work is being performed on that item or system. Closures shall be plugs, caps, blind flanges or other items specifically designed and intended for this purpose.

E. Run pipes straight and true, parallel to building lines with minimum use of offsets and couplings. Provide only offsets required to provide needed headroom or clearance and to provide needed flexibility in pipe lines.

F. Make changes in direction of pipes only with fittings or pipe bends. Changes in size only with fittings. Do not use miter fittings, face or flush bushings, or street elbows.

G. Arrange piping and connections so equipment served may be totally removed without disturbing piping beyond final connections and associated shutoff valves.

H. Use full and double lengths of pipe wherever possible.

I. Cut all pipe to exact measurement and install without springing or forcing except in the case of expansion loops where cold springing is indicated on the drawings.

J. Underground pipe shall be laid in dry trenches maintained free of accumulated water. Refer to Section 22 05 00 for Excavation, Fill, Backfill and Compaction requirements.

K. Unless otherwise indicated on the drawings, all horizontal water piping shall pitch 1" in 40 feet to low points for complete drainage back to tank.

L. Maintain accurate grade where pipes pitch or slope for drainage. No pipes shall have pockets due to changes in elevation.

M. Use eccentric reducing fittings on horizontal runs when changing size of pipes for proper drainage.

3.6 BRANCH CONNECTIONS

A. Reducers are generally not shown. Where pipe sizes change at tee, the tee shall be the size of the largest pipe shown connecting to it.

3.7 JOINING OF PIPE

A. Fusion Weld:

1. Make all field cuts of pipe square and true using a pipe cutter designed for plastic pipe.
2. Make sure proper heating heads are used for male and female situations.
3. Bevel the leading edge of pipe section with a 45° chamfer.
4. Utilize a fusion welding tool recommended and/or provided by the pipe and fitting manufacturer.
5. Not recommended for temperatures below 40°F.
6. Follow the manufacturer's cold weather installation procedures.
7. All installers shall undergo training provided by the manufacturer or manufacturer's representative.
8. Follow all manufacturer's installation instructions.

B. Solvent Weld Joints (Low-Extractable PVC):

1. Make joints conforming to manufacturer's requirements.

END OF SECTION 22 67 00

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SECTION 23 05 00 - BASIC HVAC REQUIREMENTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Requirements applicable to all Division 23 Sections. Also refer to Division 01 - General Requirements.

B. All materials and installation methods shall conform to the applicable standards, guidelines and codes referenced herein and within each specification section.

1.2 DIVISION OF WORK BETWEEN MECHANICAL, ELECTRICAL & CONTROL CONTRACTORS

A. Definitions:

1. "Mechanical Contractors" refers to the following:

   a. Plumbing Contractor.
   b. Heating Contractor.
   c. Air Conditioning and Ventilating Contractor.
   d. Temperature Control Contractor.
   e. Fire Protection Contractor.
   f. Testing, Adjusting, and Balancing Contractor.

2. Motor Control Wiring: The wiring associated with the remote operation of the magnetic coils of magnetic motor starters or relays, or the wiring that permits direct cycling of motors by means of devices in series with the motor power wiring. In the latter case the devices are usually single phase and are usually connected to the motor power wiring through a manual motor starter having "Manual-Off-Auto" provisions.
3. Control devices such as start-stop push buttons, thermostats, pressure switches, flow switches, relays, etc., generally represent the types of equipment associated with motor control wiring.
4. Motor control wiring is single phase and usually 120 volts. In some instances, the voltage will be the same as the motor power wiring. Generally, where the motor power wiring exceeds 120 volts, a control transformer is used to give a control voltage of 120 volts.
5. Temperature Control Wiring: The wiring associated with the operation of a motorized damper, solenoid valve or motorized valve, etc., either modulating or two-position, as opposed to wiring which directly powers or controls a motor used to drive equipment such as fans, pumps, etc.

   a. This wiring will be from a 120 volt source and may continue as 120 volt, or be reduced in voltage (24 volt) in which case a control transformer shall be furnished as part of the temperature control wiring.

6. Control Motor: An electric device used to operate dampers, valves, etc. It may be two-position or modulating. Conventional characteristics of such a motor are 24 volts, 60 cycles, 1 phase, although other voltages may be encountered.
7. Voltage is generally specified and scheduled as distribution voltage. Motor submittals may be based on utilization voltage if it corresponds to the correct distribution voltage.

Distribution/Nominal Voltage	Utilization Voltage
120	115
208	200
240	230
277	265
480	460

B. General:

1. The purpose of these Specifications is to outline the Electrical and Mechanical Contractor's responsibilities related to electrical work required for items such as temperature controls, mechanical equipment, fans, chillers, compressors and the like. The exact wiring requirements for much of the equipment cannot be determined until the systems have been selected and submittals reviewed. Therefore, the electrical drawings show only known wiring related to such items. All wiring not shown on the electrical drawings, but required for mechanical systems, is the responsibility of the Mechanical Contractor.
2. Where the drawings require the Electrical Contractor to wire between equipment furnished by the Mechanical Contractor, such wiring shall terminate at terminals provided in the equipment. The Mechanical Contractor shall provide complete electrical power/controls wiring diagrams and supervision to the Electrical Contractor and designate the terminal numbers for correct wiring.
3. All electrical work shall conform to the National Electrical Code. All provisions of the Electrical Specifications concerning wiring, protection, etc., apply to wiring provided by the Mechanical Contractor unless noted otherwise.
4. Control low (24V) and control line (120V) voltage wiring, conduit, and related switches and relays required for the automatic control and/or interlock of motors and equipment, including final connection, are to be furnished and installed under Divisions 21, 22 and 23. Materials and installation to conform to Class 1 or 2 requirements.
5. All Contractors shall establish utility elevations prior to fabrication and shall coordinate their material and equipment with other trades. When a conflict arises, priority is as follows:

   a. Light fixtures.
   b. Gravity flow piping, including steam and condensate.
   c. Electrical busduct.
   d. Sheet metal.
   e. Electrical cable trays, including access space.
   f. Sprinkler piping and other piping.
   g. Electrical conduits and wireway.

C. Mechanical Contractor's Responsibility:

1. Assumes responsibility for internal wiring of all equipment provided by the Mechanical Contractor, for example:

   a. Boiler Feed Pumps.
   b. Burners.
   c. Chillers.
   d. Computer Room Air Conditioning Units.
   e. Condensate Return Stations.
   f. Condensing Units.
   g. Makeup Air Units.
   h. Electric Humidifiers.
   i. Gas Trains.
   j. Package Air Handling Units.
   k. Packaged Rooftop Units.

2. Assumes all responsibility for the Temperature Control wiring, when the Temperature Control Contractor is a Subcontractor to the Mechanical Contractor.
3. Shall verify all existing equipment sizes and capacities where units are to be modified, moved or replaced. Contractor shall notify Architect/Engineer of any discrepancies prior to ordering new units or replacement parts, including replacements of equipment motors.
4. Temperature Control Subcontractor's Responsibility:

   a. Wiring of all devices needed to make the Temperature Control System functional.
   b. Verifying any control wiring on the electrical drawings as being by the Electrical Contractor. All wiring required for the Control System, but not shown on the electrical drawings, is the responsibility of the Temperature Control Subcontractor.
   c. Coordinating equipment locations (such as relays, transformers, etc.) with the Electrical Contractor, where wiring of the equipment is by the Electrical Contractor.

5. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

D. Electrical Contractor's Responsibility:

1. Provides all combination starters, manual starters and disconnect devices shown on the Electrical Drawings or indicated to be by the Electrical Contractor on the Mechanical Drawings or Specifications.
2. Installs and wires all remote control devices furnished by the Mechanical Contractor or Temperature Control Subcontractor when so noted on the Electrical Drawings.
3. Provides motor control and temperature control wiring, where so noted on the drawings.
4. Coordinate with the Mechanical Contractor for size of motors and/or other electrical devices involved with repair or replacement of existing equipment.
5. Furnishes, installs and connects all relays, etc., for automatic shutdown of certain fans upon actuation of the Fire Alarm System as indicated and specified in Division 28.
6. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

1.3 COORDINATION DRAWINGS

A. Definitions:

1. Coordination Drawings: A compilation of the pertinent layout and system drawings that show the sizes and locations, including elevations, of system components and required access areas to ensure that no two objects will occupy the same space.

   a. Mechanical trades shall include, but are not limited to, mechanical equipment, ductwork, fire protection systems, plumbing piping, medical gas systems, hydronic piping, steam and steam condensate piping, and any item that may impact coordination with other disciplines.
   b. Electrical trades shall include, but are not limited to, electrical equipment, conduit 1.5" (40 mm) and larger, conduit racks, cable trays, pull boxes, transformers, raceway, busway, lighting, ceiling-mounted devices, and any item that may impact coordination with other disciplines.
   c. Technology trades shall include, but are not limited to, technology equipment, racks, conduit 1.5" (40 mm) and larger, conduit racks, cable trays, ladder rack, pull boxes, raceway, ceiling-mounted devices, and any item that may impact coordination with other disciplines.
   d. Maintenance clearances and code-required dedicated space shall be included.
   e. The coordination drawings shall include all underground, underfloor, in-floor, in chase, and vertical trade items.

2. Spaces with open/cloud ceiling architecture shall indicate the overhead utilities and locate equipment as required to maintain clearance above lights. The intent for the installation is to maintain a maximum allowable vertical clearance and an organized/clean manner in the horizontal. Notify Architect/Engineer of the maximum clearance which can be maintained. Failure to comply will result in modifications with no cost to Owner.

   a. In cloud ceiling architecture, when open cabling/wire and/or cable tray crosses gaps between ceiling clouds and/or walls, cabling is to transition to conduits to span the gaps in order to conceal cabling from below.

3. The contractors shall use the coordination process to identify the proper sequence of installation of all utilities above ceilings and in other congested areas, to ensure an orderly and coordinated end result, and to provide adequate access for service and maintenance.

B. Participation:

1. The contractors and subcontractors responsible for work defined above shall participate in the coordination drawing process.
2. One contractor shall be designated as the Coordinating Contractor for purposes of preparing a complete set of composite electronic CAD coordination drawings that include all applicable trades, and for coordinating the activities related to this process. The Coordinating Contractor for this project shall be the Mechanical Contractor.

   a. The Coordinating Contractor shall utilize personnel familiar with requirements of this project and skilled as draftspersons/CAD operators, competent to prepare the required coordination drawings.

3. Electronic CAD drawings shall be submitted to the Coordinating Contractor for addition of work by other trades. IMEG will provide electronic file copies of ventilation drawings for contractor's use if the contractor signs and returns an "Electronic File Transfer" waiver provided by IMEG. IMEG will not consider blatant reproductions of original file copies an acceptable alternative for coordination drawings.

C. Drawing Requirements:

1. The file format and file naming convention shall be coordinated with and agreed to by all contractors participating in the coordination process and the Owner.

   a. Scale of drawings:

      1) General plans: 1/4 Inch = 1'-0" (minimum).
      2) Mechanical, electrical, communication rooms, and including the surrounding areas within 10 feet: 1/2 Inch = 1'-0" (minimum).
      3) Shafts and risers: 1/2 Inch = 1'-0" (minimum).
      4) Sections of shafts and mechanical and electrical equipment rooms: 1/4 Inch = 1'-0" (minimum).
      5) Sections of congested areas: 1/2 Inch = 1'-0" (minimum).

2. Ductwork layout drawings shall be the baseline system for other components. Ductwork layout drawings shall be modified to accommodate other components as the coordination process progresses.
3. There may be more drawings required for risers, top and bottom levels of mechanical rooms, and shafts.
4. The minimum quantity of drawings will be established at the first coordination meeting and sent to the A/E for review. Additional drawings may be required if other areas of congestion are discovered during the coordination process.

D. General:

1. Coordination drawing files shall be made available to the A/E and Owner's Representative. The A/E will only review identified conflicts and give an opinion, but will not perform as a coordinator.
2. A plotted set of coordination drawings shall be available at the project site.
3. Coordination drawings are not shop drawings and shall not be submitted as such.
4. The contract drawings are schematic in nature and do not show every fitting and appurtenance for each utility. Each contractor is expected to have included in the bid sufficient fittings, material, and labor to allow for adjustments in routing of utilities made necessary by the coordination process and to provide a complete and functional system.
5. The contractors will not be allowed additional costs or time extensions due to participation in the coordination process.
6. The contractors will not be allowed additional costs or time extensions for additional fittings, reroutings or changes of duct size, that are essentially equivalent sizes to those shown on the drawings and determined necessary through the coordination process.
7. The A/E reserves the right to determine space priority of equipment in the event of spatial conflicts or interference between equipment, piping, conduit, ducts, and equipment provided by the trades.

8. Changes to the contract documents that are necessary for systems installation and coordination shall be brought to the attention of the A/E.
9. Access panels shall preferably occur only in gypsum board walls or plaster ceilings where indicated on the drawings.
    a. Access to mechanical, electrical, technology, and other items located above the ceiling shall be through accessible lay-in ceiling tile areas.
    b. Potential layout changes shall be made to avoid additional access panels.
    c. Additional access panels shall not be allowed without written approval from the A/E at the coordination drawing stage.
    d. Providing additional access panels shall be considered after other alternatives are reviewed and discarded by the A/E and the Owner's Representative.
    e. When additional access panels are required, they shall be provided without additional cost to the Owner.
10. Complete the coordination drawing process and obtain sign off of the drawings by all contractors prior to installing any of the components.
11. Conflicts that result after the coordination drawings are signed off shall be the responsibility of the contractor or subcontractor who did not properly identify their work requirements, or installed their work without proper coordination.
12. Updated coordination drawings that reflect as-built conditions may be used as record documents.

1.4 QUALITY ASSURANCE

A. Contractor's Responsibility Prior to Submitting Pricing Data:

1. The Contractor is responsible for constructing complete and operating systems. The Contractor acknowledges and understands that the Contract Documents are a two-dimensional representation of a three-dimensional object, subject to human interpretation. This representation may include imperfect data, interpreted codes, utility guidelines, three-dimensional conflicts, and required field coordination items. Such deficiencies can be corrected when identified prior to ordering material and starting installation. The Contractor agrees to carefully study and compare the individual Contract Documents and report at once in writing to the Design Team any deficiencies the Contractor may discover. The Contractor further agrees to require each subcontractor to likewise study the documents and report at once any deficiencies discovered.
2. The Contractor shall resolve all reported deficiencies with the Architect/Engineer prior to awarding any subcontracts, ordering material, or starting any work with the Contractor's own employees. Any work performed prior to receipt of instructions from the Design Team will be done at the Contractor's risk.

B. Qualifications:

1. Only products of reputable manufacturers are acceptable.
2. All Contractors and subcontractors shall employ only workers skilled in their trades.

C. Compliance with Codes, Laws, Ordinances:

1. Conform to all requirements of the City of Springfield MO Codes, Laws, Ordinances and other regulations having jurisdiction.
2. Conform to all published standards of Missouri State University.
3. Conform to all State Codes.
4. If there is a discrepancy between the codes and regulations and these specifications, the Architect/Engineer shall determine the method or equipment used.
5. If the Contractor notes, at the time of bidding, that any parts of the drawings or specifications do not comply with the codes or regulations, Contractor shall inform the Architect/Engineer in writing, requesting a clarification. If there is insufficient time for this procedure, Contractor shall submit with the proposal a separate price to make the system comply with the codes and regulations.
6. All changes to the system made after letting of the contract, to comply with codes or requirements of Inspectors, shall be made by the Contractor without cost to the Owner.

7. If there is a discrepancy between manufacturer's recommendations and these specifications, the manufacturer's recommendations shall govern.
8. All rotating shafts and/or equipment shall be completely guarded from all contact. Partial guards and/or guards that do not meet all applicable OSHA standards are not acceptable. Contractor is responsible for providing this guarding if it is not provided with the equipment supplied.

D. Permits, Fees, Taxes, Inspections:

1. Procure all applicable permits and licenses.
2. Abide by all laws, regulations, ordinances, and other rules of the State or Political Subdivision where the work is done, or as required by any duly constituted public authority.
3. Pay all charges for permits or licenses.
4. Pay all fees and taxes imposed by the State, Municipal and/or other regulatory bodies.
5. Pay all charges arising out of required inspections by an authorized body.
6. Pay all charges arising out of required contract document reviews associated with the project and as initiated by the Owner or authorized agency/consultant.
7. Where applicable, all fixtures, equipment and materials shall be listed by Underwriters' Laboratories, Inc. and approved by FM Global.

E. Utility Company Requirements:

1. Secure from the appropriate private or public utility company all applicable requirements.
2. Comply with all utility company requirements.
3. Make application for and pay for service connections, such as gas.
4. Make application for and pay for all meters and metering systems required by the utility company.

F. Examination of Drawings:

1. The drawings for the mechanical work are completely diagrammatic, intended to convey the scope of the work and to indicate the general arrangements and locations of equipment, outlets, etc., and the approximate sizes of equipment.
2. Contractor shall determine the exact locations of equipment and rough-ins, and the exact routing of pipes and ducts to best fit the layout of the job.
3. Scaling of the drawings is not sufficient or accurate for determining these locations.
4. Where job conditions require reasonable changes in indicated arrangements and locations, such changes shall be made by the Contractor at no additional cost to the Owner.
5. Because of the scale of the drawings, certain basic items, such as fittings, boxes, valves, unions, etc., may not be shown, but where required by other sections of the specifications or required for proper installation of the work, such items shall be furnished and installed.
6. If an item is either on the drawings or in the specifications, it shall be included in this contract.
7. Determination of quantities of material and equipment required shall be made by the Contractor from the documents. Where discrepancies arise between drawings, schedules and/or specifications, the greater number shall govern.
8. Where used in mechanical documents, the word "furnish" shall mean supply for use, the word "install" shall mean connect complete and ready for operation, and the word "provide" shall mean to supply for use and connect complete and ready for operation.

   a. Any item listed as furnished shall also be installed, unless otherwise noted.
   b. Any item listed as installed shall also be furnished, unless otherwise noted.

G. Field Measurements:

1. Verify all pertinent dimensions at the job site before ordering any materials or fabricating any supports, pipes or ducts.

H. Electronic Media/Files:

1. Construction drawings for this project have been prepared utilizing Revit.
2. Contractors and Subcontractors may request electronic media files of the contract drawings and/or copies of the specifications. Specifications will be provided in PDF format.

3. Upon request for electronic media, the Contractor shall complete and return a signed "Electronic File Transmittal" form provided by IMEG.
4. If the information requested includes floor plans prepared by others, the Contractor will be responsible for obtaining approval from the appropriate Design Professional for use of that part of the document.
5. The electronic contract documents can be used for preparation of shop drawings and as-built drawings only. The information may not be used in whole or in part for any other project.
6. The drawings prepared by IMEG for bidding purposes may not be used directly for ductwork layout drawings or coordination drawings.
7. The use of these CAD documents by the Contractor does not relieve them from their responsibility for coordination of work with other trades and verification of space available for the installation.
8. The information is provided to expedite the project and assist the Contractor with no guarantee by IMEG as to the accuracy or correctness of the information provided. IMEG accepts no responsibility or liability for the Contractor's use of these documents.

1.5 SUBMITTALS

A. Submittals shall be required for the following items, and for additional items where required elsewhere in the specifications or on the drawings.

1. Submittals List:

Referenced Specification Section	Submittal Item
23 05 00	Owner Training Agenda
23 05 03	Fire Seal Systems
23 05 13	Motors
23 05 16	Expansion Compensation
23 05 48	Vibration Isolation Equipment
23 05 50	Seismic Restraint Systems
23 05 53	HVAC Identification
23 05 93	Testing, Adjusting, and Balancing
23 09 00	Controls
23 09 13	Instrumentation
23 11 23	Natural Gas and Propane Piping Systems
23 21 00	Hydronic Piping Systems and Valves
23 21 23	HVAC Pumps
23 22 00	Steam and Condensate Piping Systems and Valves
23 22 18	Traps and Condensate Return Equipment
23 25 00	Chemical Treatment Systems
23 31 00	Ductwork Layout Drawings
23 33 00	Duct Silencers
23 33 00	Fire Dampers
23 33 00	Combination Fire Smoke Dampers
23 34 13	Axial Fans
23 34 13.13	Mixed Flow Laboratory Exhaust Fans
23 34 16	Centrifugal Fans
23 34 23	Power Ventilators
23 36 00	Terminal Air Boxes
23 37 00	Grilles, Registers, and Diffusers
23 37 00	Louvers
23 57 00	Heat Exchangers
23 72 00	Energy Recovery Devices
23 73 13	Indoor Modular Air Handling Units

23 82 00	Terminal Heat Transfer Equipment
23 82 16	Coils

General Submittal Procedures: In addition to the provisions of Division 01, the following are required:

2. Transmittal: Each transmittal shall include the following:

    a. Date
    b. Project title and number
    c. Contractor's name and address
    d. Division of work (e.g., plumbing, heating, ventilating, etc.)
    e. Description of items submitted and relevant specification number
    f. Notations of deviations from the contract documents
    g. Other pertinent data

3. Submittal Cover Sheet: Each submittal shall include a cover sheet containing:

    a. Date
    b. Project title and number
    c. Architect/Engineer
    d. Contractor and subcontractors' names and addresses
    e. Supplier and manufacturer's names and addresses
    f. Division of work (e.g., plumbing, heating, ventilating, etc.)
    g. Description of item submitted (using project nomenclature) and relevant specification number
    h. Notations of deviations from the contract documents
    i. Other pertinent data
    j. Provide space for Contractor's review stamps

4. Composition:

    a. Submittals shall be submitted using specification sections and the project nomenclature for each item.
    b. Individual submittal packages shall be prepared for items in each specification section. All items within a single specification section shall be packaged together where possible. An individual submittal may contain items from multiple specifications sections if the items are intimately linked (e.g., pumps and motors).
    c. All sets shall contain an index of the items enclosed with a general topic description on the cover.

5. Content: Submittals shall include all fabrication, erection, layout, and setting drawings; manufacturers' standard drawings; schedules; descriptive literature, catalogs and brochures; performance and test data; electrical power criteria (e.g., voltage, phase, amps, horsepower, kW, etc.) wiring and control diagrams; Short Circuit Current Rating (SCCR); dimensions; shipping and operating weights; shipping splits; service clearances; and all other drawings and descriptive data of materials of construction as may be required to show that the materials, equipment or systems and the location thereof conform to the requirements of the contract documents.
6. Contractor's Approval Stamp:

    a. The Contractor shall thoroughly review and approve all shop drawings before submitting them to the Architect/Engineer. The Contractor shall stamp, date and sign each submittal certifying it has been reviewed.
    b. Unstamped submittals will be rejected.
    c. The Contractor's review shall include, but not be limited to, verification of the following:

        1) Only approved manufacturers are used.
        2) Addenda items have been incorporated.
        3) Catalog numbers and options match those specified.
        4) Performance data matches that specified.
        5) Electrical characteristics and loads match those specified.

6) Equipment connection locations, sizes, capacities, etc. have been coordinated with other affected trades.
7) Dimensions and service clearances are suitable for the intended location.
8) Equipment dimensions are coordinated with support steel, housekeeping pads, openings, etc.
9) Constructability issues are resolved (e.g., weights and dimensions are suitable for getting the item into the building and into place, sinks fit into countertops, etc.).

d. The Contractor shall review, stamp and approve all subcontractors' submittals as described above.
e. The Contractor's approval stamp is required on all submittals. Approval will indicate the Contractor's review of all material and a complete understanding of exactly what is to be furnished. Contractor shall clearly mark all deviations from the contract documents on all submittals. If deviations are not marked by the Contractor, then the item shall be required to meet all drawing and specification requirements.

7. Submittal Identification and Markings:

a. The Contractor shall clearly mark each item with the same nomenclature applied on the drawings or in the specifications.
b. The Contractor shall clearly indicate the size, finish, material, etc.
c. Where more than one model is shown on a manufacturer's sheet, the Contractor shall clearly indicate exactly which item and which data is intended.
d. All marks and identifications on the submittals shall be unambiguous.

8. Schedule submittals to expedite the project. Coordinate submission of related items.
9. Identify variations from the contract documents and product or system limitations that may be detrimental to the successful performance of the completed work.
10. Reproduction of contract documents alone is not acceptable for submittals.
11. Incomplete submittals will be rejected without review. Partial submittals will only be reviewed with prior approval from the Architect/Engineer.
12. Submittals not required by the contract documents may be returned without review.
13. The Architect/Engineer's responsibility shall be to review one set of shop drawing submittals for each product. If the first submittal is incomplete or does not comply with the drawings and/or specifications, the Contractor shall be responsible to bear the cost for the Architect/Engineer to recheck and handle the additional shop drawing submittals.
14. Submittals shall be reviewed and approved by the Architect/Engineer before releasing any equipment for manufacture or shipment.
15. Contractor's responsibility for errors, omissions. or deviation from the contract documents in submittals is not relieved by the Architect/Engineer's approval.
16. Schedule shall allow for adequate time to perform orderly and proper review of submittals, including time for consultants and Owner if required, and resubmittals by Contractor if necessary, and to cause no delay in Work or in activities of Owner or other contractors.

a. Allow at least two weeks for Architect's/Engineer's review and processing of each submittal.

17. Architect/Engineer reserves the right to withhold action on a submittal which, in the Architect/Engineer's opinion, requires coordination with other submittals until related submittals are received. The Architect/Engineer will notify the Contractor, in writing, when they exercise this right.

B. Electronic Submittal Procedures:

1. Distribution: Email submittals as attachments to all parties designated by the Architect/Engineer, unless a web-based submittal program is used.
2. Transmittals: Each submittal shall include an individual electronic letter of transmittal.
3. Format: Electronic submittals shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Submittals that are not legible will be rejected. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.

4. File Names: Electronic submittal file names shall include the relevant specification section number followed by a description of the item submitted, as follows. Where possible, include the transmittal as the first page of the PDF instead of using multiple electronic files.

   a. Submittal file name: 23 XX XX.description.YYYYMMDD
   b. Transmittal file name: 23 XX XX.description.YYYYMMDD

5. File Size: Files shall be transmitted via a pre-approved method. Larger files may require an alternative transfer method, which shall also be pre-approved.

1.6 EQUIPMENT SUPPLIERS' INSPECTION

A. The following equipment shall not be placed in operation until a competent installation and service representative of the manufacturer has inspected the installation and certified that the equipment is properly installed, adjusted and lubricated; that preliminary operating instructions have been given; and that the equipment is ready for operation:

   1. Air Cooled Condensers
   2. Base Mounted Pumps
   3. Boilers, Burners and Boiler Trim
   4. Computer Room Units
   5. Condensing Units
   6. Cooling Towers
   7. Gas Fired Makeup Air Units
   8. Fire Seal Systems
   9. Fluid Coolers
   10. Seismic Restraints and Equipment Bracing
   11. Water Chillers

B. Contractor shall arrange for and obtain supplier's on-site inspection(s) at proper time(s) to assure each phase of equipment installation and/or connection is in accordance with the manufacturer's instructions.

C. Submit copies of start-up reports to the Architect/Engineer and include copies of Owner's Operation and Maintenance Manuals.

1.7 PRODUCT DELIVERY, STORAGE, HANDLING & MAINTENANCE

A. Exercise care in transporting and handling to avoid damage to materials. Store materials on the site to prevent damage. Keep materials clean, dry and free from harmful conditions. Immediately remove any materials that become wet or that are suspected of becoming contaminated with mold or other organisms.

B. Keep all bearings properly lubricated and all belts properly tensioned and aligned.

C. Coordinate the installation of heavy and large equipment with the General Contractor and/or Owner. If the Mechanical Contractor does not have prior documented experience in rigging and lifting similar equipment, he/she shall contract with a qualified lifting and rigging service that has similar documented experience. Follow all equipment lifting and support guidelines for handling and moving.

D. Contractor is responsible for moving equipment into the building and/or site. Contractor shall review site prior to bid for path locations and any required building modifications to allow movement of equipment. Contractor shall coordinate the work with other trades.

1.8 NETWORK / INTERNET CONNECTED EQUIPMENT

A. These specifications may require certain equipment or systems to have network, Internet and/or remote access capability ("Network Capability"). Any requirement for Network Capability shall be interpreted only as a functional capability and is not to be construed as authority to connect or enable any Network Capability. Network Capability may only be connected or enabled with the express written consent of the Owner.

1.9 WARRANTY

A. Provide one-year warranty, unless otherwise noted, to the Owner for all fixtures, equipment, materials, and workmanship.

B. The warranty period for all work in this Division of the specifications shall commence on the date of final acceptance, unless a whole or partial system or any separate piece of equipment or component is put into use for the benefit of any party other than the installing contractor with prior written authorization. In this instance, the warranty period shall commence on the date when such whole system, partial system or separate piece of equipment or component is placed in operation and accepted in writing by the Owner.

C. Warranty requirements shall extend to correction, without cost to the Owner, of all Work found to be defective or nonconforming to the contract documents. The Contractor shall bear the cost of correcting all damage resulting from defects or nonconformance with contract documents.

1.10 INSURANCE

A. Contractor shall maintain insurance coverage as set forth in Division 0 of these specifications.

1.11 MATERIAL SUBSTITUTION

A. Where several manufacturers' names are given, the scheduled manufacturer is the basis for job design and establishes the quality required.

B. Equivalent equipment manufactured by the other listed manufacturers may be used. Contractor shall ensure that all items submitted by these other manufacturers meet all requirements of the drawings and specifications and fits in the allocated space. When using other listed manufacturers, the Contractor shall assume responsibility for any and all modifications necessary (including, but not limited to structural supports, electrical connections, piping and ductwork connections and arrangement, plumbing connections and rough-in, and regulatory agency approval, etc.) and coordinate such with other contractors.

C. Any material, article or equipment of other unnamed manufacturers which will adequately perform the services and duties imposed by the design and is of a quality equal to or better than the material, article or equipment identified by the drawings and specifications may be used if approval is secured in writing from the Architect/Engineer not later than ten days prior to the bid opening.

D. This Contractor assumes all costs incurred as a result of using the offered material, article or equipment, on the Contractors part or on the part of other Contractors whose work is affected.

E. This Contractor may list voluntary add or deduct prices for alternate materials on the bid form. These items will not be used in determining the low bidder.

F. All material substitutions requested later than ten (10) days prior to bid opening must be listed as voluntary changes on the bid form.

1.12 PROJECT COMMISSIONING

A. The Contractor shall work with the Commissioning Agent (CxA) as described in Section 01 91 00 and 23 08 00 and provide all services as described in the Commissioning Plan.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 JOBSITE SAFETY

A. Neither the professional activities of the Architect/Engineer, nor the presence of the Architect/Engineer or the employees and subconsultants at a construction site, shall relieve the Contractor and other entity of their obligations, duties and responsibilities including, but not limited to, construction means, methods, sequence, techniques or procedures necessary for performing, superintending or coordinating all portions of the work of construction in accordance with the contract documents and any health or safety precautions required by any regulatory agencies. The Architect/Engineer and personnel have no authority to exercise any control over any construction contractor or other entity or their employees in connection with their work or any health or safety precautions. The Contractor is solely responsible for jobsite safety. The Architect/Engineer and the Architect/Engineer's consultants shall be indemnified and shall be made additional insureds under the Contractor's general liability insurance policy.

3.2 EXCAVATION, FILL, BACKFILL, COMPACTION

A. General:

1. Prior to the commencement of any excavation or digging, the Contractor shall verify all underground utilities with the regional utility locator. Provide prior notice to the locator before excavations. Contact information for most regional utility locaters can be found at the following website (https://call811.com/) or by calling 811.
2. The Contractor shall do all excavating, filling, backfilling and compacting associated with the work.

B. Excavation:

1. Make all excavations to accurate, solid, undisturbed earth, and to proper dimensions.
2. Where excavations are made in error below foundations, concrete of same strength as specified for the foundations or thoroughly compacted sand-gravel fill, as determined by the Architect/Engineer, shall be placed in such excess excavations. Place thoroughly compacted, clean, stable fill in excess excavations under slabs on grade, at the Contractor's expense.
3. Trim bottom and sides of excavations to grades required for foundations.
4. Protect excavations against frost and freezing.
5. Take care in excavating not to damage surrounding structures, equipment, or buried pipe. Do not undermine footing or foundation.
6. Perform all trenching in a manner to prevent cave-ins and risk to workers.
7. Where original surface is pavement or concrete, the surface shall be saw cut to provide clean edges and assist in the surface restoration.
8. Where satisfactory bearing soil for foundations is not found at the indicated levels, the Architect/Engineer or their representative shall be notified immediately, and no further work shall be done until further instructions are given by the Architect/Engineer or their representative.

C. Dewatering:

1. Contractor shall furnish, install, operate, and remove all dewatering pumps and pipes needed to keep trenches and pits free of water.

D. Underground Obstructions:

1. Known underground piping, foundations, and other obstructions in the vicinity of construction are shown on the drawings. Use great care in making installations near underground obstruction.
2. If objects not shown on the drawings are encountered, remove, relocate, or perform extra work as directed by the Architect/Engineer.

E. Fill and Backfilling:

1. Utilities Bedding: Lay underground utilities on minimum of 6"sand bedding or CA6 crushed stone. Compact bedding under utilities smooth, with no sharp edges protruding, to protect the utilities from puncture. Shape bedding to provide continuous support for bells, joints, and barrels of utilities and for joints and fittings.
2. Envelope around utilities to 6" above utilities: Place and compact sand or CA6 to a height of 6" over utilities in 6" layers. Each layer shall be placed, then carefully and uniformly tamped, to eliminate lateral or vertical displacement. After connection joints are made, any misalignment can be corrected by tamping backfill around the utilities.
3. Backfill from 6" above utilities to earthen grade: Place all backfill materials above the utilities in uniform layers not exceeding 6" deep. Each layer shall be placed, then carefully and uniformly tamped, to eliminate lateral or vertical displacement.
4. Backfill from 6" above utilities to below slabs or paved area: Where the fill and backfill will ultimately be under a building, floor or paving, each layer of backfill materials shall be compacted to 95% of the maximum density determined by AASHTO Designation T 99 or ASTM Designation D 698. Moisture content of soil at time of compaction shall not exceed plus or minus 2% of optimum moisture content determined by AASHTO T 99 or ASTM D 698 test.
5. Backfill Materials: Native soil materials may be used as backfill if approved by the Geotechnical Engineer. Backfill material shall be free of rock or gravel larger than 3" in any dimension and shall be free of debris, waste, frozen materials, vegetation, high void content, and other deleterious materials. Water shall not be permitted to rise in unbackfilled trenches.
6. Dispose of excess excavated earth as directed.
7. Backfill all trenches and excavations immediately after installing utilities or removal of forms, unless other protection is provided.
8. Around piers and isolated foundations and structures, backfill and fill shall be placed and consolidated simultaneously on all sides to prevent wedge action and displacement. Fill and backfill materials shall be spread in 6 inch uniform horizontal layers with each layer compacted separately to required density.

F. Surface Restoration:

1. Where trenches are cut through existing graded, planted, or landscaped areas, the areas shall be restored to the original condition. Replace all planting removed or damaged to its original condition. A minimum of 6 inches of topsoil shall be applied where disturbed areas are to be seeded or sodded.
2. Concrete or asphalt type pavement, seal coat, rock, gravel or earth surfaces removed or damaged shall be replaced with comparable materials and restored to original condition.

3.3 ARCHITECT/ENGINEER OBSERVATION OF WORK

A. The Contractor shall provide seven (7) calendar days' notice to the Architect/Engineer prior to:

1. Placing fill over underground and underslab utilities.
2. Covering exterior walls, interior partitions and chases.
3. Installing hard or suspended ceilings and soffits.

B. The Architect/Engineer will have the opportunity to review the installation and provide a written report noting deficiencies requiring correction. The Contractor's schedule shall account for these reviews and show them as line items in the approved schedule.

C. Above-Ceiling Final Observation

1. All work above the ceilings must be complete prior to the Architect/Engineer's review. This includes, but is not limited to:

   a. Pipe insulation is installed and fully sealed.
   b. Pipe and duct wall penetrations are sealed.
   c. Pipe identification and valve tags are installed.
   d. Main, branch and flexible ducts are installed.
   e. Diffusers, registers and grilles are installed and connected to ductwork.
   f. Terminal air box reheat coil piping or wiring is complete.
   g. Terminal air box control wiring is complete and all control boxes are closed.

2. In order to prevent the Above-Ceiling Final Observation from occurring too early, the Contractor shall review the status of the work and certify, in writing, that the work is ready for the Above-Ceiling Final Observation.
3. It is understood that if the Architect/Engineer finds the ceilings have been installed prior to this review and prior to 7 days elapsing, the Architect/Engineer may not recommend further payments to the contractor until such time as full access has been provided.

3.4 PROJECT CLOSEOUT

A. The following paragraphs supplement the requirements of Division 01.

B. Final Jobsite Observation:

1. In order to prevent the Final Jobsite Observation from occurring too early, the Contractor is required to review the completion status of the project and certify that the job is ready for the final jobsite observation.
2. Attached to the end of this section is a typical list of items that represent the degree of job completeness expected prior to requesting a review.
3. Upon Contractor certification that the project is complete and ready for a final observation, the Contractor shall sign the attached certification and return it to the Architect/Engineer so that the final observation can be scheduled.
4. It is understood that if the Architect/Engineer finds the job not ready for the final observation and that additional trips and observations are required to bring the project to completion, the costs incurred by the Architect/Engineer's additional time and expenses will be deducted from the Contractor's contract retainage prior to final payment at the completion of the job.

C. Before final payment is authorized, this Contractor must submit the following:

1. Operation and maintenance manuals with copies of approved shop drawings.
2. Record documents including marked-up or reproducible drawings and specifications.
3. A report documenting the instructions given to the Owner's representatives complete with the number of hours spent in the instruction. The report shall bear the signature of an authorized agent of This Contractor and shall be signed by the Owner's representatives.
4. Inspection by State Boiler Inspector.
5. Start-up reports on all equipment requiring a factory installation inspection or start-up.
6. Provide spare parts, maintenance, and extra materials in quantities specified in individual specification sections. Deliver to project site and place in location as directed; receipt by Architect/Engineer required prior to final payment approval.

3.5 OPERATION AND MAINTENANCE MANUALS

A. General:

1. Provide an electronic copy of the O&M manuals as described below for Architect/Engineer's review and approval. The electronic copy shall be corrected as required to address the Architect/Engineer's comments. Once corrected, electronic copies and paper copies shall be distributed as directed by the Architect/Engineer.
2. Approved O&M manuals shall be completed and in the Owner's possession prior to Owner's acceptance and at least 10 days prior to instruction of operating personnel.

B. Electronic Submittal Procedures:

1. Distribution: Email the O&M manual as attachments to all parties designated by the Architect/Engineer.
2. Transmittals: Each submittal shall include an individual electronic letter of transmittal.
3. Format: Electronic submittals shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Submittals that are not legible will be rejected. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.
4. File Names: Electronic submittal file names shall include the relevant specification section number followed by a description of the item submitted, as follows. Where possible, include the transmittal as the first page of the PDF instead of using multiple electronic files.

    a. O&M file name: O&M.div23.contractor.YYYYMMDD
    b. Transmittal file name: O&Mtransmittal.div23.contractor.YYYYMMDD

5. File Size: Files shall be transmitted via a pre-approved method. Larger files may require an alternative transfer method, which shall also be pre-approved.
6. Provide the Owner with an approved copy of the O&M manual on compact discs (CD), digital video discs (DVD), or flash drives with a permanently affixed label, printed with the title "Operation and Maintenance Instructions", title of the project and subject matter of disc/flash drive when multiple disc/flash drives are required.
7. All text shall be searchable.
8. Bookmarks shall be used, dividing information first by specification section, then systems, major equipment and finally individual items. All bookmark titles shall include the nomenclature used in the construction documents and shall be an active link to the first page of the section being referenced.

C. Operation and Maintenance Instructions shall include:

1. Title Page: Include title page with project title, Architect, Engineer, Contractor, all subcontractors, and major equipment suppliers, with addresses, telephone numbers, website addresses, email addresses and point of contacts. Website URLs and email addresses shall be active links in the electronic submittal.
2. Table of Contents: Include a table of contents describing specification section, systems, major equipment, and individual items.
3. Copies of all final approved shop drawings and submittals. Include Architect's/Engineer's shop drawing review comments. Insert the individual shop drawing directly after the Operation and Maintenance information for the item(s) in the review form.
4. Refer to Section 23 09 00 for additional requirements for Temperature Control submittals.
5. Copy of final approved test and balance reports.
6. Copies of all factory inspections and/or equipment startup reports.
7. Copies of warranties.
8. Schematic electrical power/controls wiring diagrams of the equipment that have been updated for field conditions. Field wiring shall have label numbers to match drawings.
9. Dimensional drawings of equipment.
10. Capacities and utility consumption of equipment.
11. Detailed parts lists with lists of suppliers.
12. Operating procedures for each system.
13. Maintenance schedule and procedures. Include a chart listing maintenance requirements and frequency.

14. Repair procedures for major components.
15. List of lubricants in all equipment and recommended frequency of lubrication.
16. Instruction books, cards, and manuals furnished with the equipment.

3.6 INSTRUCTING THE OWNER'S REPRESENTATIVES

A. Adequately instruct the Owner's designated representatives in the maintenance, care, and operation of all systems installed under this contract.

B. Provide verbal and written instructions to the Owner's representatives by FACTORY PERSONNEL in the care, maintenance, and operation of the equipment and systems.

C. The Owner has the option to make a video recording of all instructions. Coordinate schedule of instructions to facilitate this recording.

D. The instructions shall include:

1. Explanation of all system flow diagrams.
2. Explanation of all air handling systems.
3. Temperature control system operation including calibration, adjustment and proper operating conditions of all sensors.
4. Maintenance of equipment.
5. Smoke control systems.
6. Stairwell pressurization systems.
7. Start-up procedures for all major equipment.
8. Explanation of seasonal system changes.
9. Description of emergency system operation.

E. Notify the Architect/Engineer of the time and place for the verbal instructions to be given to the Owner's representative so a representative can attend if desired.

F. Minimum hours of instruction for each item shall be:

1. Water Softener System - 4 hours.
2. Heating Water System - 4 hours.
3. Chilled Water System - 4 hours.
4. Steam/Condensate System - 4 hours.
5. Chemical Treatment System - As defined in Section 23 25 00.
6. Air Handling System(s) - 8 hours.
7. Exhaust System(s) - 8 hours.
8. Temperature Controls - As defined in Section 23 09 00.

G. The Contractor shall prepare a detailed, written training agenda and submit it to the Architect/Engineer a minimum of four weeks prior to the formal training for approval. The written agenda shall include specific training points within the items described above. For example: how to adjust setpoints, troubleshooting, proper start-up, proper shut-down, seasonal changes, draining, venting, changing filters, changing belts, etc. Failure to provide and follow an approved training agenda may result in additional training required at the expense of the Contractor.

H. Operating Instructions:

1. Contractor is responsible for all instructions to the Owner's representatives for the mechanical and control systems.
2. If the Contractor does not have staff that can adequately provide the required instructions the Contractor shall include in the bid an adequate amount to reimburse the Owner for the Architect/Engineer to perform these services.

3.7 SYSTEM STARTING AND ADJUSTING

A. The mechanical systems shall be complete and operating. System startup, testing, adjusting, and balancing to obtain satisfactory system performance is the responsibility of the Contractor. This includes calibration and adjustments of all controls, noise level adjustments and final comfort adjustments as required.

B. Complete all manufacturer-recommended startup procedures and checklists to verify proper motor rotation, electrical power voltage is within equipment limitations, equipment controls maintain pressures and temperatures within acceptable ranges, all filters and protective guards are in-place, acceptable access is provided for maintenance and servicing, and equipment operation does not pose a danger to personnel or property.

C. Operate all HVAC systems continuously for at least one week prior to occupancy to bring construction materials to suitable moisture levels. Areas with mechanical cooling shall be maintained below 60% RH.

D. Contractor shall adjust the mechanical systems and controls at season changes during the one year warranty period, as required, to provide satisfactory operation and to prove performance of all systems in all seasons.

E. All operating conditions and control sequences shall be tested during the start-up period. Test all interlocks, safety shutdowns, controls, and alarms.

F. The Contractor, subcontractors, and equipment suppliers shall have skilled technicians to ensure that all systems perform properly. If the Architect/Engineer is requested to visit the job site for trouble shooting, assisting in start-up, obtaining satisfactory equipment operation, resolving installation and/or workmanship problems, equipment substitution issues or unsatisfactory system performance, including call backs during the warranty period, through no fault of the design; the Contractor shall reimburse the Owner on a time and materials basis for services rendered at the Architect/Engineer's standard hourly rates in effect when the services are requested. The Contractor shall pay the Owner for services required that are product, installation or workmanship related. Payment is due within 30 days after services are rendered.

3.8 RECORD DOCUMENTS

A. The following paragraphs supplement Division 01 requirements.

B. Maintain at the job site a separate and complete set of mechanical drawings and specifications with all changes made to the systems clearly and permanently marked in complete detail.

C. Mark drawings to indicate revisions to piping and ductwork, size and location, both exterior and interior; including locations of coils, dampers, other control devices, filters, and other units requiring periodic maintenance or repair; actual equipment locations, dimensioned from column lines; actual inverts and locations of underground piping; concealed equipment, dimensioned from column lines; mains and branches of piping systems, with valves and control devices located and numbered, concealed unions located, and with items requiring maintenance located (e.g., traps, strainers, expansion compensators, tanks, etc.); Change Orders; concealed control system devices.

D. Refer to Section 23 09 00 for additional requirements for Temperature Control documents.

E. Before completion of the project, a set of reproducible mechanical drawings will be given to the Contractor for transfer of all as-built conditions from the paper set maintained at the job site. All marks on reproducibles shall be clear and permanent.

F. Mark specifications to show approved substitutions; Change Orders, and actual equipment and materials used.

G. Record changes daily and keep the marked drawings available for the Architect/Engineer's examination at any normal work time.

H. Upon completing the job, and before final payment is made, give the marked-up drawings to the Architect/Engineer.

3.9 ADJUST AND CLEAN

A. Thoroughly clean all equipment and systems prior to the Owner's final acceptance of the project. Clean all foreign paint, grease, oil, dirt, labels, stickers, and other foreign material from all equipment.

B. Clean all drain pans and areas where moisture is present. Immediately report any mold, biological growth, or water damage.

C. Remove all rust, scale, dirt, oils, stickers and thoroughly clean exterior of all exposed bare metal ductwork, piping, hangers, and accessories.

D. Remove all rubbish, debris, etc., accumulated during construction from the premises.

3.10 SPECIAL REQUIREMENTS

A. Contractor shall coordinate the installation of all equipment, valves, dampers, operators, etc., with other trades to maintain clear access area for servicing.

B. All equipment shall be installed in such a way to maximize access to parts needing service or maintenance. Review the final field location, placement, and orientation of equipment with the Owner's designated representative prior to setting equipment.

C. Installation of equipment or devices without regard to coordination of access requirements and confirmation with the Owner's designated representative will result in removal and reinstallation of the equipment at the Contractor's expense.

3.11 IAQ MAINTENANCE FOR OCCUPIED FACILITIES UNDER CONSTRUCTION

A. Contractors shall make all reasonable efforts to prevent construction activities from affecting the air quality of the occupied areas of the building or outdoor areas near the building. These measures shall include, but not be limited to:

1. All contractors shall endeavor to minimize the amount of contaminants generated during construction. Methods to be employed shall include, but not be limited to:

    a. Minimizing the amount of dust generated.
    b. Reducing solvent fumes and VOC emissions.
    c. Maintain good housekeeping practices, including sweeping and periodic dust and debris removal. There should be no visible haze in the air.
    d. Protect stored on-site and installed absorptive materials from moisture damage.

2. Request that the Owner designate an IAQ representative.
3. Review and receive approval from the Owner's IAQ representative for all IAQ-related construction activities and negative pressure containment plans.
4. Inform the IAQ representative of all conditions that could adversely impact IAQ, including operations that will produce higher than normal dust production or odors.
5. Schedule activities that may cause IAQ conditions that are not acceptable to the Owner's IAQ representative during unoccupied periods.
6. Request copies of and follow all of the Owner's IAQ and infection control policies.
7. Unless no other access is possible, the entrance to construction site shall not be through the existing facility.
8. To minimize growth of infectious organisms, do not permit damp areas in or near the construction area to remain for over 24 hours.

9. In addition to the criteria above, provide measures as recommended in the SMACNA "IAQ Guidelines for Occupied Buildings Under Construction".
10. If permanently installed air handlers are used to serve both construction and occupied areas, all return grilles throughout construction areas shall be sealed to prevent air from construction areas being supplied to occupied areas.
11. If permanently installed air handlers are used during construction to serve only construction areas and do not supply air to adjacent occupied areas, MERV 8 filtration media shall be used to protect each return air grille or opening. The intent of this will be to prevent construction dust and debris from entering any return or supply air ductwork in the facility. All filtration media shall be replaced immediately prior to occupancy.
12. Construction areas shall be maintained at a negative pressure at all times during construction. When areas are under construction, HEPA filtered exhaust fan(s) shall be installed in sufficient quantities as required to maintain construction areas at sufficient negative pressure as called for in the Owner's Infection Control Risk Assessment (ICRA). HEPA filtered exhaust fan discharge shall be ducted either outdoors or back into designated hospital areas as called for in the Owner's ICRA.
13. For each area under construction, the Contractor shall install a negative pressure indicator equivalent to Lamiflow Model L-102F as manufactured by Lamiflow Technologies. Contractor shall regularly monitor and record the negative pressure condition of the construction areas as called for in the Owner's ICRA.

3.12 MAINTAINING CLEAN DUCTWORK THROUGHOUT CONSTRUCTION

A. Throughout the duration of construction, all ductwork shall be capped or sealed with sheet metal caps, polyethylene film, or other airtight protective to keep dust, dirt, and construction debris out of ducts. Similar means shall be used to seal air-side connections of HVAC equipment to include, but not limited to, air handling units, fans, terminal air boxes, fan coil units, cabinet heaters, blower coils, and the like.

B. When air terminal devices are installed, contractors shall seal all supply, return, and exhaust grilles with polyethylene film or other airtight protective to keep dust, dirt, and construction debris out of ducts.

C. Should HVAC equipment be started during construction, Contractor shall remove airtight protectives and shall install one-inch thick MERV 8 filter media over all return and exhaust grilles to prevent dust, dirt, and construction debris from entering ductwork. Filter media shall cover the entire grille face and shall be secured such that air cannot bypass filter media.

D. Should filter media become laden with dust and dirt, Contractor shall replace filter media with new media to prevent damage to air distribution system and equipment.

E. The following steps shall be taken during testing, adjusting, and balancing of each air system:

1. All construction activities in all spaces served by the air system shall stop.
2. All airtight protectives and temporary filter media shall be removed from all portions of the air system.
3. Testing, adjusting, and balancing work shall not commence until all construction activity is stopped and all airtight protectives and temporary filter media is removed.
4. Once testing, adjusting, and balancing work is complete for the air system, airtight protectives or temporary filter media shall be installed over all ductwork openings and air terminals on the air system prior to resuming construction activities in any spaces served by the air system.

F. The Owner shall agree the building is sufficiently clean prior to the removal of any filtration media and airtight protectives from air terminal devices.

3.13 UTILITY REBATE

A. Submit utility rebate forms, where offered at project location, with rebate items completed. Rebate may include lighting, lighting controls, variable speed drives, heat pumps, package terminal A/C, air conditioners, chillers, water heaters, programmable thermostats, and motors.

B. Contractor must submit notification of any value engineering or product substitution that will affect the utility rebate amount prior to approval.

END OF SECTION 23 05 00

SECTION 23 05 05 - HVAC DEMOLITION FOR REMODELING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Mechanical demolition.

B. Cutting and Patching.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Materials and equipment shall be as specified in individual Sections.

PART 3 - EXECUTION

3.1 EXAMINATION

A. THE DRAWINGS ARE INTENDED TO INDICATE THE GENERAL SCOPE OF WORK AND DO NOT SHOW EVERY PIPE, DUCT, OR PIECE OF EQUIPMENT THAT MUST BE REMOVED. THE CONTRACTOR SHALL VISIT THE SITE AND VERIFY CONDITIONS PRIOR TO SUBMITTING A BID.

B. Where walls, ceilings, etc., are shown as being removed on general drawings, the Contractor shall remove all mechanical equipment, devices, fixtures, piping, ducts, systems, etc., from the removed area.

C. Where ceilings, walls, partitions, etc., are temporarily removed and replaced by others, This Contractor shall remove, store, and replace equipment, devices, fixtures, pipes, ducts, systems, etc.

D. Verify that abandoned utilities serve only abandoned equipment or facilities. Extend services to facilities or equipment that shall remain in operation following demolition.

E. Coordinate work with all other Contractors and the Owner. Schedule removal of equipment to avoid conflicts.

F. This Contractor shall verify all existing equipment sizes and capacities where equipment is scheduled to be replaced or modified, prior to ordering new equipment.

G. Bid submittal shall mean the Contractor has visited the project site and verified existing conditions and scope of work.

3.2 PREPARATION

A. Disconnect mechanical systems in walls, floors, and ceilings scheduled for removal.

B. Provide temporary connections to maintain existing systems in service during construction. When work must be performed on operating equipment, use personnel experienced in such operations.

C. Existing Heating System: Maintain existing system in service until new system is complete and ready for service. Drain system only to make switchovers and connections. Obtain permission from the Owner at least 48 hours before partially or completely draining system. Minimize outage duration.

3.3 DEMOLITION AND EXTENSION OF EXISTING MECHANICAL WORK

A. Demolish and extend existing mechanical work under provisions of Division 2 and this Section.

B. Remove, relocate, and extend existing installations to accommodate new construction.

C. Remove abandoned ducts and piping to source of supply and/or main lines.

D. Remove exposed abandoned pipes and ducts, including abandoned pipes and ducts above accessible ceilings. Cut ducts flush with walls and floors, cap duct that remains, and patch surfaces. Cut pipes above ceilings, below floors and behind walls. Cap remaining lines. Repair building construction to match original. Remove all clamps, hangers, supports, etc. associated with pipe and duct removal.

E. Disconnect and remove mechanical devices and equipment serving equipment that has been removed.

F. Repair adjacent construction and finishes damaged during demolition and extension work.

G. Maintain access to existing mechanical installations which remain. Modify installation or provide access panels as appropriate.

H. Remove unused sections of supply and return air ductwork back to mains. Patch opening with sheet metal and seal airtight. Patch existing insulation to match existing. Where existing ductwork is to be capped and reused, locate the end cap within 6" of the last branch. End caps shall be 3" pressure class and seal class "A".

I. Extend existing installations using materials and methods compatible with existing installations, or as specified.

3.4 CUTTING AND PATCHING

A. This Contractor is responsible for all penetrations of existing construction required to complete the work of this project. Refer to Section 23 05 29 for additional requirements.

B. Penetrations in existing construction should be reviewed carefully prior to proceeding with any work.

C. Penetrations shall be neat and clean with smooth and/or finished edges. Core drill where possible for clean opening.

D. Repair existing construction as required after penetration is complete to restore to original condition. Use similar materials and match adjacent construction unless otherwise noted or agreed to by the Architect/Engineer prior to start of work.

E. Floor slab is post-tensioned. All penetrations shall be x-rayed prior to cutting and/or drilling to avoid any tension cables or utilities encased in floor construction.

F. Floor slabs may contain conduit systems. This Contractor is responsible for taking any measures required to ensure no conduits or other services are damaged. This includes x-ray or similar non-destructive means.

G. This Contractor is responsible for <u>all</u> costs incurred in repair, relocations, or replacement of any cables, conduits, or other services if damaged without proper investigation.

3.5 CLEANING AND REPAIR

A. Clean and repair existing materials and equipment which remain or are to be reused.

B. Clean all systems adjacent to project which are affected by the dust and debris caused by this construction.

C. MECHANICAL ITEMS REMOVED AND NOT RELOCATED REMAIN THE PROPERTY OF THE OWNER. CONTRACTOR SHALL PLACE ITEMS RETAINED BY THE OWNER IN A LOCATION COORDINATED WITH THE OWNER. THE CONTRACTOR SHALL DISPOSE OF MATERIAL THE OWNER DOES NOT WANT TO REUSE OR RETAIN FOR MAINTENANCE PURPOSES.

3.6 SPECIAL REQUIREMENTS

A. Install temporary filter media over outside air intakes which are within 100 feet of the limits of construction or as noted on the drawings. This Contractor shall complete any cleaning required for existing systems which are affected by construction dust and debris.

B. Review locations of all new penetrations in existing floor slabs or walls. Determine construction type and review for possible interferences. Bring all concerns to the attention of the Architect/Engineer before proceeding.

END OF SECTION 23 05 05

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SECTION 23 05 13 - MOTORS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Single Phase and Three Phase Electric Motors.

1.2 SUBMITTALS

A. Submit shop drawings under provisions of Section 23 05 00. Include nominal efficiency and power factor for all premium efficiency motors. Efficiencies must meet or exceed the nominal energy efficiency levels presented below.

B. Submit shop drawings for <u>all</u> three phase motors.

C. Submit motor data with equipment when motor is installed by the manufacturer at the factory.

D. Submit shaft grounding rings or brushes or ceramic bearings for all motors as required.

1.3 DELIVERY, STORAGE, AND HANDLING

A. Protect motors stored on site from weather and moisture by maintaining factory covers and suitable weatherproof coverings. For extended outdoor storage, follow manufacturer's recommendations for equipment and motor.

1.4 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data including assembly drawings, bearing data including replacement sizes, and lubrication instructions.

1.5 QUALIFICATIONS

A. Manufacturer: Company specializing in the manufacture of commercial and industrial motors and accessories, with a minimum of three years documented manufacturing experience.

PART 2 - PRODUCTS

2.1 MOTORS - GENERAL CONSTRUCTION AND REQUIREMENTS

A. Refer to the drawings for required electrical characteristics. Voltage is generally specified and scheduled as distribution voltage. Motor submittals may be based on utilization voltage if it corresponds to the correct distribution voltage.

Distribution/Nominal Voltage	Utilization Voltage
120	115
208	200
240	230

277	265
480	460

B. Design motors for continuous operation in 40ºC environment, and for temperature rise in accordance with ANSI/NEMA MG 1 limits for insulation class, service factor, and motor enclosure type.

C. Explosion-Proof Motors: UL listed and labeled for the hazard classification shown on the drawing, with over-temperature protection.

D. Visible Nameplate: Indicating horsepower, voltage, phase, hertz, RPM, full load amps, locked rotor amps, frame size, manufacturer's name and model number, service factor, power factor, insulation class.

E. Electrical Connection: Boxes, threaded for conduit. For fractional horsepower motors where connection is made directly, provide conduit connection in end frame.

F. Unless otherwise indicated, motors 3/4 HP and smaller shall be single phase, 60 hertz, open drip-proof or totally enclosed fan-cooled type.

G. Unless otherwise indicated, motors 1 HP and larger shall be three phase, 60 hertz, squirrel cage type, NEMA Design Code B (low current in-rush, normal starting torque), open drip-proof or totally enclosed fan-cooled type.

H. Each contractor shall set all motors furnished by him.

I. All motors shall have a minimum service factor of 1.15.

J. All motors shall have ball or roller bearings with a minimum L-10 fatigue life of 150,000 hours in direct-coupled applications and 50,000 hours for belted applications. Belted rating shall be based on radial loads and pulley sizes called out in NEMA MG1-14.43.

K. Bearings shall be sealed type for 10 HP and smaller motors. Bearings shall be regreasable type for larger motors.

L. Aluminum end housings are not permitted on motors 15 HP or larger.

M. Motor Driven Equipment:

1. No equipment shall be selected or operate above 90% of its motor nameplate rating. Motor size may not be increased to compensate for equipment with efficiency lower than that specified.
2. If a larger motor than specified is required on equipment, the contractor supplying the equipment is responsible for all additional costs due to larger starters, wiring, etc.

N. Provide all belted motors with a means of moving and securing the motor to tighten belts. Motors over 2 HP shall have screw type tension adjustment. Motors over 40 HP shall have dual screw adjusters. Slide bases shall conform to NEMA standards.

O. Motors for fans and pumps 1/12 HP or greater and less than 1 HP shall be electronically-commutated motors or shall have a minimum motor efficiency of 70% when rated in accordance with DOE 10 CFR 431. These motors shall also have the means to adjust motor speed for either balancing or remote control. Belt-driven fans may use sheave adjustments for airflow balancing in lieu of varying motor speed.

2.2 ELECTRICALLY COMMUTATED MOTORS (ECM)

A. Motor shall be variable speed, constant torque, brushless DC motor for direct-drive applications. Electronics shall be encapsulated for moisture protection and shall integral surge protection. Motor shall be pre-wired for specific voltage and phase.

B. Motor frame shall be NEMA 48; UL recognized components shall be provided for the motor construction.

C. All EC motors shall be a minimum of 85% efficient at all speeds.

D. Motors shall be permanently lubricated; utilize ball bearings to match with the connected driven equipment.

E. Provide motor with on-board motor control module. Motor speed shall be limited to provide electronic over current protection. Starter shall provide soft start to reduce inrush current and shall be controllable from 20% to 100% of full rated speed.

F. Operational mode shall be as scheduled and shall be one of the following:

1. Constant Flow
2. Constant Temperature
3. Constant Pressure

2.3 PREMIUM EFFICIENCY MOTORS (INCLUDING MOST 3-PHASE GENERAL PURPOSE MOTORS)

A. All motors, unless exempted by EPAct legislation that became federal law on December 19, 2010, shall comply with the efficiencies listed in that standard, which are reprinted below. These match the 2010 NEMA premium efficiency ratings. All ratings listed are nominal full load efficiencies, verified in accordance with IEEE Standard 112, Test Method B. Average expected (not guaranteed minimum) power factors shall also be at least the following:

	Full-Load Efficiencies %					
	Open Drip-Proof			Totally Enclosed Fan Cooled		
HP	1200 rpm	1800 rpm	3600 rpm	1200 rpm	1800 rpm	3600 rpm
1.0	82.5	85.5	77.0	82.5	85.5	77.0
1.5	86.5	86.5	84.0	87.5	86.5	84.0
2.0	87.5	86.5	85.5	88.5	86.5	85.5
3.0	88.5	89.5	85.5	89.5	89.5	86.5
5.0	89.5	89.5	86.5	89.5	89.5	88.5
7.5	90.2	91.0	88.5	91.0	91.7	89.5
10.0	91.7	91.7	89.5	91.0	91.7	90.2
15.0	91.7	93.0	90.2	91.7	92.4	91.0
20.0	92.4	93.0	91.0	91.7	93.0	91.0
25.0	93.0	93.6	91.7	93.0	93.6	91.7
30.0	93.6	94.1	91.7	93.0	93.6	91.7
40.0	94.1	94.1	92.4	94.1	94.1	92.4
50.0	94.1	94.5	93.0	94.1	94.5	93.0
60.0	94.5	95.0	93.6	94.5	95.0	93.6
75.0	94.5	95.0	93.6	94.5	95.4	93.6
100.0	95.0	95.4	93.6	95.0	95.4	94.1

B. Motor nameplate shall be noted with the above ratings.

2.4 MOTORS ON VARIABLE FREQUENCY DRIVES

A. All motors driven by VFDs shall be premium efficiency type.

B. Motors shall be designed for use with VFDs in variable torque applications with 1.15 service factor. Motors shall <u>not</u> be equipped with auxiliary blowers.

C. Motors driven by VFDs shall have Class F or H insulation and be designated by the motor manufacturer to be suitable for inverter duty service in accordance with NEMA MG 1 Section IV, "Performance Standards Applying to All Machines," Part 31 "Definite-Purpose Inverter-Fed Polyphase Motors.

D. All 480 volt motors driven by VFDs shall be provided with shaft grounding rings or grounding brushes or ceramic bearings as a means to protect bearings from adverse shaft currents.

1. Providing grounding rings internal to the motor housing is an acceptable solution, provided the motor is affixed with a label clearly indicating the presence of a grounding assembly. The grounding ring shall be listed for 40,000 hours of motor service and shall be accessible via the drive endplate.
2. Motor shafts 2" and larger require shaft grounding on the drive end and the non-drive end. This Contractor shall ensure (via field observation and measurement) that the shaft is effectively grounded upon startup.

2.5 MOTORS FOR WET OR CORROSIVE DUTY

A. Where noted for wet and/or corrosive duty, motors shall be designed for severe duty with cast-iron frame, epoxy finish, stainless steel nameplate, polymer shaft seal, corrosion resistant fasteners and fan, moisture resistant windings, and non-wicking leads.

2.6 MOTORS FOR HAZARDOUS DUTY

A. Where noted for hazardous duty, motors shall be designed for the class, group, and T code listed for the application. Frame sizes 143T and larger shall have normally closed winding thermostats to keep surface temperatures below the nameplate T code under all conditions.

2.7 SHEAVES

A. All sheaves shall conform to NEMA Standard MG1-14.42, which lists minimum diameters and maximum overhangs. Locate motors to minimize overhang.

B. When replacing sheaves, use sheaves of at least the originally supplied sizes.

C. Contractor responsible for motor shall also be responsible for replacement sheaves. Coordinate with testing and balancing of the equipment.

PART 3 - EXECUTION

3.1 INSTALLATION

A. All rotating shafts and/or equipment shall be completely guarded from all contact. Partial guards and/or guards that do not meet all applicable OSHA standards are not acceptable. Contractor is responsible for providing this guarding if it is not provided with the equipment supplied.

B. For flexible coupled drive motors, mount coupling to the shafts in accordance with the coupling manufacturer's recommendations. Align shafts to manufacturer's requirements or within 0.002 inch per inch diameter of coupling hub.

C. For belt drive motors, mount sheaves on the appropriate shafts per manufacturer's instructions. Use electronic sheave/belt alignment equipment to check alignment of the sheaves. Reposition sheaves as necessary so the straight edge contacts both sheave faces squarely. After sheaves are aligned, loosen the adjustable motor base so the belt(s) can be added, and tighten the base so the belt tension is in accordance with the drive manufacturer's recommendations. Frequently check belt tension and adjust if necessary during the first day of operation and again after 80 hours of operation.

END OF SECTION 23 05 13

SECTION 23 05 16 - HVAC EXPANSION COMPENSATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Expansion Joints and Compensators.

B. Pipe Loops, Offsets, and Swing Joints.

1.2 REFERENCES

A. Conform to Standards of Expansion Joint Manufacturer's Association.

1.3 SUBMITTALS

A. Submit shop drawings under provisions of Section 23 05 00.

B. Expansion joint shop drawings shall include maximum motion.

1.4 DESIGN CRITERIA

A. Unless noted otherwise, base expansion calculations on 50°F installation temperature to 210°F for heating water and steam condensate, plus 30% safety factor. Contact Architect/Engineer for steam temperatures.

PART 2 - PRODUCTS

2.1 EXPANSION JOINTS

A. Type EJ-1:

1. Multiple plies of 300 series stainless steel bellows.
2. Rated for 150 psi working pressure at 250°F and 100psi at 400°F.
3. Cycle life shall be at least 1,000 full range (compression and extension) cycles at rated stroke and 6,000 cycles at 1/2 rated stroke.
4. Axial motion shall be as scheduled on the drawings, but not less than 2” (compression plus extension).
5. Provide stainless steel inner liner for all steam expansion joints.
6. Provide removable metal insulation shroud around the bellows.
7. Joints 2" or smaller in copper piping systems shall have all copper, brass or bronze construction with stainless steel bellows and union ends or sweat ends with unions added.

    a. Manufacturers:

        1) American BOA Type KH
        2) Hyspan Type 8509
        3) Flexonics Model HB
        4) Metraflex Model HPMF
        5) Keflex Series 7QT

8. Joints 2” or smaller in ferrous piping systems shall have steel bodies with union ends or male threaded ends with unions added.

    a. Manufacturers:

        1) American BOA Type B
        2) Hyspan Type 8503
        3) Flexonics Model H
        4) Metraflex Model HP
        5) Keflex Series 7Q-MPT

9. Joints 2-1/2" or larger shall have 150 lb. forged steel flanges.

    a. Manufacturers:

        1) American BOA Model 3150FS or 3150FL
        2) Hyspan Model 1501
        3) RM Model X-Flex-150 Multiply
        4) Keflex Series 311-1215
        5) Metraflex Model MNLC

B. Type EJ-2:

1. Multiple plies of 300 series stainless steel bellows.
2. Rated for 300 psi working pressure at 800°F.
3. Cycle life shall be at least 1,000 full range (compression and extension) cycles at rated stroke and 6,000 cycles at 1/2 rated stroke.
4. Axial motion shall be as scheduled on the drawings, but not less than 2” (compression and extension).
5. Joints shall have 300 lb. flanges on each end.
6. Provide stainless steel inner liner.
7. Provide removable metal insulation shroud around the bellows.

    a. Manufacturers:

        1) American BOA Type FS3300
        2) Flexonics
        3) RM Model X-Flex-300 Multiply
        4) Hyspan Model 1501

C. Type EJ-3:

1. Offset hinged or gimbal mounted, self-equalizing expansion joints with stainless steel carriers.
2. Suitable for vacuum to 300 psig .

    a. Manufacturers:

        1) Barco Manufacturing
        2) Metraflex Model MC

D. Type EJ-4:

1. Assembly consisting of two flexible connectors, two stainless steel flexible connectors, two 90° elbows, and a 180° return pipe. Unit shall be in the form of a pipe loop.
2. Connectors shall have corrugated stainless hose bodies with stainless steel braided casings.
3. Connectors shall be rated for 150 psi working pressure at 70°F and 100 psi at 800°F .
4. Sizes 2” and smaller shall have steel threaded connections.
5. Sizes 2-1/2” and larger shall have 150 lb. steel flanges.
6. Connectors shall be suitable for 1/2” permanent misalignment.

a. Manufacturer:

1) Metraflex Type ML

E. Alignment Guides:

1. Bolted semi-steel spider.
2. Bolted guiding cylinder with supporting legs welded to pipe support.
3. Sized to allow insulation to pass through the outer cylinder.

a. Manufacturers:

1) American BOA
2) Hyspan
3) Flexonics
4) Keflex
5) Metraflex

F. Concrete Thrust Blocks - Rods and Clamps:

1. Bends, offsets, tees, crosses, and dead ends, including flange and spigot pieces, shall be suitably rodded or clamped and blocked with concrete thrust blocks.
2. Rods shall be all thread type, galvanized steel conforming to ANSI B1.1, Class 2A FIT, USS National Coarse Thread, tensile strength 55/77 ksi, yield strength 36 ksi minimum.
3. Rods and clamps shall receive one field coat of asphaltum after installation.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Accomplish structural work and provide equipment required to control expansion and contraction of piping; including loops, offsets, swing joints, and expansion joints where required.

B. Rigidly anchor pipe to building structure where necessary. Provide pipe guides so all movement occurs along axis of pipe only.

C. Each mechanical expansion joint shall have one anchor on each side and two alignment guides on each side of it. Guides shall be located within 4 and 14 pipe diameters of the mechanical expansion joint or as recommended by the joint manufacturer.

D. Preset all expansion joints to allow for expected expansion from installation temperature to operating temperature.

END OF SECTION 23 05 16

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SECTION 23 05 29 - HVAC SUPPORTS AND ANCHORS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Hangers, Supports, and Associated Anchors.

B. Equipment Bases and Supports.

C. Sleeves and Seals.

D. Flashing and Sealing of Equipment and Pipe Stacks.

E. Cutting of Openings.

F. Escutcheon Plates and Trim.

1.2 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 23 05 00. Include plastic pipe manufacturers' support spacing requirements.

1.3 WORK FURNISHED BUT INSTALLED UNDER OTHER SECTIONS

A. Furnish sleeves and hanger inserts to General Contractor for placement into formwork.

PART 2 - PRODUCTS

2.1 SEISMIC RESTRAINTS

A. Refer to Section 23 05 50 for additional requirements for seismic restraints.

2.2 HANGER RODS

A. Hanger rods for single rod hangers shall conform to the following:
1. Steel Pipe:

a. Hanger Rod Diameter:

1) 2-1/2" and smaller: 3/8"
2) 3" through 3-5/8": 3/8"
3) 4" through 6": 1/2"
4) 8": 5/8"
5) 10": 3/4"
6) 12": 7/8"
7) 14" and 16": 1"
8) 18" and 24": 1-1/4")

2. Copper, Plastic and Fiberglass Reinforced Pipe:

   a. Hanger Rod Diameter:

      1) 2-1/2" and smaller: 3/8"
      2) 3") through 3-5/8": 3/8"
      3) 4") through 6": 1/2"
      4) 8": 5/8"
      5) 10": 3/4"
      6) 12": 7/8"
      7) 14" and 16": 1"
      8) 18" and 24": 1-1/4"

B. Rods for double rod hangers may be reduced one size. Minimum rod diameter is 3/8 inches.

C. Hanger rods and accessories used in mechanical spaces or otherwise dry areas shall have ASTM B633 electro-plated zinc finish.

2.3 PIPE AND STRUCTURAL SUPPORTS

A. General:

1. Pipe hangers, clamps, and supports shall conform to Manufacturers Standardization Society MSS SP-58, 69, 89, and 127 (where applicable).
2. On all insulated piping, provide at each support an insert of same thickness and contour as adjoining insulation, between the pipe and insulation jacket, to prevent insulation from sagging and crushing. Refer to insulation specifications for materials and additional information.

B. Vertical Supports:

1. Support and laterally brace vertical pipes at every floor level in multi-story structures, unless otherwise noted by applicable codes, but never at intervals over 15 feet. Support vertical pipes with riser clamps installed below hubs, couplings, or lugs. Provide sufficient flexibility to accommodate expansion and contraction to avoid compromising fire barrier penetrations or stressing piping at fixed takeoff locations.

   a. Products:

      1) Eaton Fig B3373 Series
      2) nVent 510 Series
      3) Anvil Fig. 90

2. Cold Pipe: Place restrained neoprene mounts beneath vertical pipe riser clamps to prevent sweating of cold pipes. Select neoprene mounts based on the weight of the pipe to be supported. Insulate over mounts.

   a. Products:

      1) Mason RBA, RCA or RDA
      2) Mason BR

3. Cold Pipe Alternative: Insulated pipe riser clamp with no thermal bridging between clamp and pipe; water repellant calcium silicate insulation material adhered inside the clamp; ASTM A653 galvanized steel clamp.

   a. Products:

      1) Pipeshields E100

4. Wall supports shall be used where vertical height of structure exceeds minimum spacing requirements. Install wall supports at same spacing as hangers or strut supports along vertical length of pipe runs. Wall supports shall be coordinated with the Structural Engineer.
5. Masonry Anchors: Fasten to concrete masonry units with expansion anchors or self-tapping masonry screws. For expansion anchors into hollow concrete block, use sleeve-type anchors designed for the specific application. Do not fasten in masonry joints. Do not use powder actuated fasteners, wooden plugs, or plastic inserts.

C. Hangers and Clamps:

1. Oversize all hangers, clamps, and supports on insulated piping to allow insulation and jacket to pass through unbroken. This applies to both hot and cold pipes.
2. Hangers in direct contact with bare copper pipe shall include plastic pipe insert similar to Unistrut Cush-A-Clamp, Hydra-Zorb, nVent Cushion Clamp or Eaton Vibra-Clamp within their temperature limits of -65°F to +275°F.
3. On all insulated piping, provide a semi-cylindrical metallic shield and vapor barrier jacket.
4. Ferrous hot piping 4 inches and larger shall have steel saddles tack welded to the pipe at each support with a depth not less than specified for the insulation. Factory fabricated inserts may be used.

    a. Products:

        1) Anvil Fig. 160, 161, 162, 163, 164, 165
        2) Eaton Fig. 3160, 3161, 3162, 3163, 3164, 3165
        3) nVent Model 630, 631, 632, 633, 634, 635

5. Unless otherwise indicated, hangers shall be as follows:

    a. Clevis Type: Service: Bare Metal Pipe, Rigid Plastic Pipe, Insulated Cold Pipe, Insulated Hot Pipe - 3 inches and Smaller:

        1) Products: Bare Steel, Plastic or Insulated Pipe:

            a) Anvil Fig. 260
            b) Eaton Fig. 3100
            c) nVent Model 400

        2) Products: Bare Copper Pipe:

            a) Eaton Fig. B3104F or B3100CTC
            b) Anvil Fig. CT65
            c) nVent Fig. 402

    b. Roller Type: Service: Insulated Hot Pipe - 4 inches and Larger:

        1) Products: 4" through 6":

            a) Anvil Fig. 181, 271
            b) Eaton Fig. 3110
            c) nVent Model 610

        2) Products: 8" and Above:

            a) Anvil Fig. 171, 271
            b) Eaton Fig. 3114, 3117
            c) nVent Model 605

c. Continuous Channel with Clevis Type: Service: Plastic Tubing, Flexible Hose, Soft Copper Tubing:

1) Products:

a) Eaton Fig. B3106, with Fig. B3106V
b) nVent Model 104, with Model 104V
c) Anvil Fig. 1V

d. Adjustable Swivel Ring Type: Service: Bare Metal Pipe - 4 inches and Smaller:

1) Products: Bare Steel Pipe:

a) Anvil Fig. 69
b) Eaton Fig. B3170NF
c) nVent Model 115

2) Products: Bare Copper Pipe:

a) Eaton Fig. B3170CTC
b) nVent 102A0 Series
c) Anvil Fig. CT-69

6. Support may be fabricated from U-channel strut or similar shapes. Piping less than 4" in diameter shall be secured to strut with clamps of proper design and capacity as required to maintain spacing and alignment. Strut shall be independently supported from hanger drops or building structure. Size and support shall be per manufacturer's installation requirements for structural support of piping. Clamps shall not interrupt piping insulation.

a. Strut used in mechanical spaces or otherwise dry areas shall have ASTM B633 electro-plated zinc finish.
b. Strut used in damp areas listed in hanger rods shall have ASTM A123 hot-dip galvanized finish applied after fabrication.

7. Unless otherwise indicated, pipe supports for use with struts shall be as follows:

a. Clamp Type: Service: Bare Metal Pipe, Rigid Plastic Pipe, Insulated Cold Pipe, Insulated Hot Pipe - 3 inches and smaller:

1) Clamps in direct contact with copper pipe shall include plastic pipe insert similar to Unistrut Cush-A-Clamp, Hydra-Zorb, nVent Cushion Clamp or Eaton Vibra-Clamp.
2) Pipes subject to expansion and contraction shall have clamps oversized to allow limited pipe movement.
3) Products: Bare Steel, Plastic or Insulated Pipe:

a) Unistrut Fig. P1100 or P2500
b) Eaton Fig. B2000 or B2400
c) Anvil Fig. AS1200
d) nVent USC

4) Products: Bare Copper Pipe:

a) Eaton Fig. BVT
b) nVent CADDY Cushion Clamp

b. Roller Type: Service: Insulated Hot Pipe - 4 inches and larger:

1) Products: 4" through 6":

a) Unistrut Fig. P2474
b) Eaton Fig. B218
c) Anvil Fig. ROL-12
d) nVent ROL12

2) Products: 8" and Above:

a) Unistrut Fig. P2474-1
b) Eaton Fig. B219
c) nVent Fig. ROL-13
d) Anvil AS1902

D. Upper (Structural) Attachments:

1. Unless otherwise shown, upper attachments for hanger rods or support struts shall be as follows:

a. Steel Structure Clamps: C-Type Wide Flange Beam Clamps (for use on top and/or bottom of wide flanges. Not permitted for use with bar-joists.):

1) Products:

a) Anvil Fig. 86
b) Eaton Fig. B3033/B3034
c) nVent Model 300 & 310

b. Scissor Type Beam Clamps (for use with bar-joists and wide flange):

1) Products:

a) Anvil Fig. 228, 292
b) Eaton Fig. B3054
c) nVent Model 360

c. Concentrically Loaded Open Web Joist Hangers (for use with bar joists):

1) Products:

a) MCL. M1, M2 or M3

d. Concrete: Inserts Single Rod Galvanized:

1) Products:

a) Anvil Fig. 282
b) Eaton Fig. B3014
c) nVent Model 355

e. Concrete: Inserts Continuous Strip Galvanized:

1) Products:

a) Unistrut Corp P3200 Series
b) Eaton Fig. B22
c) nVent CONB
d) Anvil AS249

f. Concrete Anchors: Fasten to concrete using cast-in or post-installed anchors designed per the requirements of Appendix D of ACI 318-11. Post-installed anchors shall be qualified for use in cracked concrete by ACI-355.2.
g. Masonry Anchors: Fasten to concrete masonry units with expansion anchors or self-tapping masonry screws. For expansion anchors into hollow concrete block, use sleeve-type anchors designed for the specific application. Do not fasten in masonry joints. Do not use powder actuated fasteners, wooden plugs, or plastic inserts.
h. Steel Structure Welding:

1) Unless otherwise noted, hangers, clips, and auxiliary support steel may be welded in lieu of bolting, clamping, or riveting to the building structural frame. Take adequate precautions during all welding operations for fire prevention and protecting walls and ceilings from smoke damage.

i. Wood Anchors: Tension wood rod hanger for suspending 3/8" threaded rod. Zinc plated carbon steel.

1) Minimum allowable tension loads for Douglass Fir/Southern Pine:

a) 3/8" diameter rod; 2-1/2" shank: 600 lb/590 lb.
b) Load values are based on full shank penetration into wood member. Minimum edge distance 3/4". Minimum end distance 3-1/4".

2) Limitations:

a) Truss: Do not hang from wood trusses without truss manufacturer or Structural Engineer’s approval.
b) Sheetrock/Gypsum Ceiling: When drilling through non-wood materials (e.g., sheet rock, gypsum, etc.), increase shank length by depth of non-wood materials.
c) Plywood Flooring/Roofing: Do not hang from plywood floor or roofing.
d) Spacing: Refer to wood structure spacing of hangers.

3) Products:

a) Simpson RWV
b) DeWALT
c) ITI Sammys GT25

2.4 FOUNDATIONS, BASES, AND SUPPORTS

A. Basic Requirements:

1. Furnish and install foundations, bases, and supports (not specifically indicated on the Drawings or in the Specifications of either the General Construction or Mechanical work as provided by another Contractor) for mechanical equipment.
2. All concrete foundations, bases and supports, shall be reinforced. All steel bases and supports shall receive a prime coat of zinc chromate or red metal primer. After completion of work, give steel supports a final coat of gray enamel.

B. Concrete Bases (Housekeeping Pads):

1. Refer to Section 23 05 50 for additional requirements for concrete bases in seismic applications.
2. Unless shown otherwise on the drawings, concrete bases shall be nominal 4 inches thick and shall extend 3 inches on all sides of the equipment (6 inches larger than factory base), except where pad extension would interfere with working space at equipment control panels and electrical panels.
3. Where a base is less than 12 inches from a wall, extend the base to the wall to prevent a "dirt-trap".

4. Concrete materials and workmanship required for the Contractor's work shall be provided by the Contractor. Materials and workmanship shall conform to the applicable standards of the Portland Cement Association. Reinforce with 6"x6", W1.4-W1.4 welded wire fabric. Concrete shall withstand 3,000 pounds compression per square inch at 28 days (be 20 MPa strength).
5. Equipment requiring bases is as follows:

    a. Air Handling Unit
    b. Expansion Tank
    c. Heat Exchanger
    d. Pump

C. Supports:

1. Provide sufficient clips, inserts, hangers, racks, rods, and auxiliary steel to securely support all suspended material, equipment and conduit without sag.
2. Hang heavy equipment from concrete floors or ceilings with Architect/Engineer-approved concrete inserts, furnished and installed by the Contractor whose work requires them, except where indicated otherwise.

D. Grout:

1. Grout shall be non-shrinking premixed (Master Builders Company "Embecco"), unless otherwise indicated on the drawings or approved by the Architect/Engineer.
2. Use Mix No. 1 for clearances of 1" or less, and Mix No. 2 for all larger clearances.
3. Grout under equipment bases, around pipes, at pipe sleeves, etc., and where shown on the drawings.

2.5 OPENINGS IN FLOORS, WALLS AND CEILINGS

A. Exact locations of all openings for the installation of materials shall be determined by the Contractor and given to the General Contractor for installation or construction as the structure is built.

B. Coordinate all openings with other Contractors.

C. Hire the proper tradesman and furnish all labor, material and equipment to cut openings in or through existing structures, or openings in new structures that were not installed, or additional openings. Repair all spalling and damage to the satisfaction of the Architect/Engineer. Make saw cuts before breaking out concrete to ensure even and uniform opening edges.

D. Said cutting shall be at the complete expense of each Contractor. Failure to coordinate openings with other Contractors shall not exempt the Contractor from providing openings at Contractor's expense.

E. Do not cut structural members without written approval of the Architect or Structural Engineer.

F. Exposed Housing Penetrations: Seal pipes with surface temperature below 150°F, penetrating housings with conical stepped, white silicone, EPDM or neoprene pipe flashings and stainless steel clamps equal to Portals Plus Pipe Boots or Pipetite.

2.6 ROOF PENETRATIONS

A. Roof Curb Enclosure: Provide weatherproof roof curb and enclosure for pipe and duct penetrations. Refer to drawings for details.

B. Conical Pipe Boot: Seal pipes with surface temperature below 150°F penetrating single-ply roofs with conical stepped, UV-resistant silicone, EPDM or neoprene pipe flashings and stainless steel clamps equal to Portals Plus Pipe Boots or Pipetite. Color: White shall match roofing material.

C. Break insulation only at the clamp for pipes between 60°F and 150°F. Seal outdoor insulation edges watertight.

2.7 Rooftop Duct Supports

A. Performance Based Design by Contractor and manufacturer

B. Mechanical Contractor shall coordinate with manufacturer for the design and install of a roof top duct support system as well as required restraint to the building structure for wind and seismic loads.

C. System design and installation shall include all requirements by the Authority Having Jurisdiction, local and state building codes, and Owner's insurance company in addition to the previously listed design standard(s). Those requirements shall take precedence over the contract documents in the case of discrepancies.

D. Approved Manufacturers

1. Miro
2. Unistrut
3. Approved Alternate

E. Refer to detail and rooftop duct layout on drawings for required information.

F. Rooftop Duct Layout

1. Dimensions of Ductwork
2. Duct Material and Gauge/Thickness
3. Clearance Height Above roof to be minimum 24”
4. Additional information shown in detail including building occupancy, wind design criteria and seismic design criteria.

G. Rooftop duct supports to be stainless steel construction

H. Final design to be fully coordinated with structural engineer of record prior to submittal.

2.8 SLEEVES AND LINTELS

A. Each Contractor shall provide sleeves and lintels for all duct and pipe openings required for the Contractor's work in masonry walls and floors, unless specifically shown as being by others.

B. Fabricate all sleeves from standard weight black steel pipe or as indicated on the drawings. Provide continuous sleeve. Cut or split sleeves are not acceptable.

C. Fabricate all lintels for masonry walls from structural steel shapes or as indicated on the drawings. Have all lintels approved by the Architect or Structural Engineer.

D. Sleeves through the floors on exposed risers shall be flush with the ceiling, with planed squared ends extending 1" above the floor in unfinished areas, and flush with the floor in finished areas, to accept spring closing floor plates.

E. Sleeves shall not penetrate structural members or masonry walls without approval from the Structural Engineer. Sleeves shall then comply with the Architect/Engineer's design.

F. Openings through unexcavated floors and/or foundation walls below the floor shall have a smooth finish with sufficient annular space around material passing through opening so slight settling will not place stress on the material or building structure.

G. Install all sleeves concentric with pipes. Secure sleeves in concrete to wood forms. This Contractor is responsible for sleeves dislodged or moved when pouring concrete.

H. Where pipes rise through concrete floors that are on earthen grade, provide 3/4" resilient expansion joint material (e.g., foam, rubber, asphalt-coated fiber, bituminous-impregnated felt, or cork) wrapped around the pipe, the full depth of concrete, at the point of penetration. Secure to prevent shifting during concrete placement and finishing.

I. Size sleeves large enough to allow expansion and contraction movement. Provide continuous insulation wrapping.

J. Wall Seals ("Link-Seals"):

1. Where shown on the drawings, pipes passing through walls, ceilings, or floors shall have their annular space (sleeve or drilled hole - not tapered hole made with knockout plug) sealed by properly sized sealing elements consisting of a synthetic rubber material compounded to resist aging, ozone, sunlight, water and chemical action.
2. Sleeves, if used, shall be standard weight steel with primed finish and waterstop/anchor continuously welded to sleeve. If piping carries only fluids below 120°F, sleeves may be thermoplastic with integral water seal and textured surface.
3. Sleeves shall be at least 2 pipe sizes larger than the pipes.
4. Pressure shall be maintained by stainless steel bolts and other parts. Pressure plates may be of composite material for Models S and OS.
5. Sealing element shall be as follows:

Model	Service	Element Material	Temperature Range
S	Standard (Stainless)	EPDM	-40°F to 250°F
T	High/Low Temperature (Steam)	Silicone	-67°F to 400°F
T	Fire Seals (1 hour)	Silicone	-67°F to 400°F
FS	Fire Seals (3 hours)	Silicone	-67°F to 400°F
OS	Oil Resistant/Stainless	Nitrile	-40°F to 210°F

6. Manufacturers:

a. Thunderline Corporation "Link-Seals"
b. O-Z/Gedney Company
c. Calpico, Inc.
d. Innerlynx
e. Metraflex Company (cold service only)
f. Polywater PHSD

2.9 ESCUTCHEON PLATES AND TRIM

A. Fit escutcheons to all insulated or uninsulated exposed pipes passing through walls, floors, or ceilings of finished rooms.

B. Escutcheons shall be heavy gauge, cold rolled steel, copper coated under a chromium plated finish, heavy spring clip, rigid hinge and latch.

C. Install galvanized steel (unless otherwise indicated) trim strip to cover vacant space and raw construction edges of all rectangular openings in finished rooms. This includes pipe openings.

2.10 PIPE PENETRATIONS

A. Seal all pipe penetrations. Seal non-rated walls and floor penetrations with grout or caulk. Backing material may be used.

B. Seal fire rated wall and floor penetrations with fire seal system as specified.

2.11 PIPE ANCHORS

A. Provide all items needed to allow adequate expansion and contraction of all piping. All piping shall be supported, guided, aligned, and anchored as required.

B. Repair all piping leaks and associated damage. Pipes shall not rub on any part of the building.

2.12 FINISH

A. Prime coat exposed steel hangers and supports. Hangers and supports in crawl spaces, pipe shafts, and suspended ceiling spaces are not considered exposed.

PART 3 - EXECUTION

3.1 HVAC SUPPORTS AND ANCHORS

A. General Installation Requirements:

1. Install all items per manufacturer's instructions.
2. Coordinate the location and method of support of piping systems with all installations under other Divisions and Sections of the Specifications.
3. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.
4. Supports shall extend directly to building structure. Do not support piping from duct hangers unless coordinated with Sheet Metal Contractor prior to installation. Do not allow lighting or ceiling supports to be hung from piping supports.

B. Supports Requirements:

1. Where building structural steel is fireproofed, all hangers, clamps, auxiliary steel, etc., which attach to it shall be installed prior to application of fireproofing. Repair all fireproofing damaged during pipe installation.
2. Set all concrete inserts in place before pouring concrete.
3. Furnish, install and prime all auxiliary structural steel for support of piping systems that are not shown on the Drawings as being by others.
4. Install hangers and supports complete with lock nuts, clamps, rods, bolts, couplings, swivels, inserts and required accessories.
5. Hangers for horizontal piping shall have adequate means of vertical adjustment for alignment.

C. Pipe Requirements:

1. Support all piping and equipment, including valves, strainers, traps and other specialties and accessories to avoid objectionable or excessive stress, deflection, swaying, sagging or vibration in the piping or building structure during erection, cleaning, testing and normal operation of the systems.
2. Do not, however, restrain piping to cause it to snake or buckle between supports or to prevent proper movement due to expansion and contraction.

3. Support piping at equipment and valves so they can be disconnected and removed without further supporting the piping.
4. Piping shall not introduce strains or distortion to connected equipment.
5. Parallel horizontal pipes may be supported on trapeze hangers made of structural shapes and hanger rods; otherwise, pipes shall be supported with individual hangers.
6. Trapeze hangers may be used where ducts interfere with normal pipe hanging.
7. Provide additional supports where pipe changes direction, adjacent to flanged valves and strainers, at equipment connections and heavy fittings.
8. Provide at least one hanger adjacent to each joint in grooved end steel pipe with mechanical couplings.

D. Provided the installation complies with all loading requirements of truss and joist manufacturers, the following practices are acceptable:

1. Loads of 100 lbs. or less may be attached anywhere along the top or bottom chords of trusses or joists with a minimum 3' spacing between loads.
2. Loads greater than 100 lbs. must be hung concentrically and may be hung from top or bottom chord, provided one of the following conditions is met:

   a. The hanger is attached within 6" from a web/chord joint.
   b. Additional L2x2x1/4 web reinforcement is installed per manufacturer's requirements.

3. It is prohibited to cantilever a load using an angle or other structural component that is attached to a truss or joist in such a fashion that a torsional force is applied to that structural member.
4. If conditions cannot be met, coordinate installation with truss or joist manufacturer and contact Architect/Engineer.

E. After piping and insulation installation are complete, cut hanger rods back at trapeze supports so they do not extend more than 3/4" below bottom face of lowest fastener and blunt any sharp edges.

F. Do not exceed 25 lbs. per hanger and a minimum spacing of 2'-0" on center when attaching to metal roof decking (limitation not required with concrete on metal deck). This 25 lbs. load and 2'-0" spacing include adjacent electrical and architectural items hanging from deck. If the hanger restrictions cannot be achieved, supplemental framing off steel framing will need to be added.

G. Do not exceed the manufacturer's recommended maximum load for any hanger or support.

H. Steel/Concrete Structure: Spacing of hangers shall not exceed the compressive strength of the insulation inserts, and in no case shall exceed the following:

1. Steel and Fiberglass (Std. Weight or Heavier - Liquid Service):

   a. Maximum Spacing:

      1) 1-1/4" & under: 7'-0"
      2) 1-1/2": 9'-0"
      3) 2": 10'-0"
      4) 2-1/2": 11'-0"
      5) 3": 12'-0"
      6) 4" & larger: 12'-0"

2. Steel (Std. Weight or Heavier - Vapor Service):

   a. Maximum Spacing:

      1) 1-1/4" and under: 9'-0"
      2) 1-1/2": 12'-0"
      3) 2" & larger: 12'-0"

3. Hard Drawn Copper & Brass (Liquid Service):

   a. Maximum Spacing:

      1) 3/4" and under: 5'-0"
      2) 1": 6'-0"
      3) 1-1/4": 7'-0"
      4) 1-1/2" 8'-0"
      5) 2": 8'-0"
      6) 2-1/2": 9'-0"
      7) 3": 10'-0"
      8) 4": 12'-0"
      9) 6": 12'-0"

4. Hard Drawn Copper & Brass (Vapor Service):

   a. Maximum Spacing:

      1) 3/4" & under: 7'-0"
      2) 1": 8'-0"
      3) 1-1/4": 9'-0"
      4) 1-1/2": 10'-0"
      5) 2": 11'-0"
      6) 2-1/2" & larger: 12'-0"

5. Plastic Pipe:

   a. Hangers shall be spaced based on the piping system manufacturer's instructions or, if no system instructions are available, space hangers at 4'-0" maximum centers.

6. Ultra-Flexible Pipe, Flexible Hose, and Soft Copper Tubing:

   a. Continuous channel with hangers maximum 8'-0" OC.

I. Wood Structure: Spacing of hangers shall not exceed the compressive strength of the insulation inserts, and in no case shall exceed the following:

1. Steel and Fiberglass (Std. Weight or Heavier - Liquid Service):

   a. Maximum Spacing:

      1) 1-1/4" & under: 7'-0"
      2) 1-1/2": 9'-0"
      3) 2": 10'-0"
      4) 2-1/2": 11'-0"
      5) 3": 12'-0"
      6) 4" through 6": 12'-0"8": 9’-0"10": 6’-0"12": 4’-0"

2. Steel (Std. Weight or Heavier - Vapor Service):

   a. Maximum Spacing:

      1) 1-1/4" and under: 9'-0"
      2) 1-1/2": 12'-0"
      3) 2" & larger: 12'-0"
      4) 2-1/2": 11'-0"
      5) 3": 12'-0"
      6) 4" through 8": 12'-0"
      7) 10": 9’-0"
      8) 12": 6’-0"

3. Hard Drawn Copper & Brass (Liquid Service):

   a. Maximum Spacing:

      1) 3/4" and under: 5'-0"
      2) 1": 6'-0"
      3) 1-1/4": 7'-0"
      4) 1-1/2" 8'-0"
      5) 2": 8'-0"
      6) 2-1/2": 9'-0"
      7) 3": 10'-0"
      8) 4": 12'-0"
      9) 6": 12'-0"

4. Hard Drawn Copper & Brass (Vapor Service):

   a. Maximum Spacing:

      1) 3/4" & under: 7'-0"
      2) 1": 8'-0"
      3) 1-1/4": 9'-0"
      4) 1-1/2": 10'-0"
      5) 2": 11'-0"
      6) 2-1/2" & larger: 12'-0"

5. Plastic Pipe:

   a. Hangers shall be spaced based on the piping system manufacturer's instructions or, if no system instructions are available, space hangers at 4'-0" maximum centers.

6. Ultra-Flexible Pipe, Flexible Hose, and Soft Copper Tubing:

   a. Continuous channel with hangers maximum 8'-0" OC.

J. Wood Structure: Spacing of hangers shall not exceed the compressive strength of the insulation inserts, and in no case shall exceed the following:

1. Steel and Fiberglass (Std. Weight or Heavier - Liquid Service):

   a. Maximum Spacing:

      1) 1-1/4" & under: 7'-0"
      2) 1-1/2": 9'-0"
      3) 2": 10'-0"
      4) 2-1/2": 11'-0"
      5) 3": 12'-0"
      6) 4" through 6": 12'-0"8": 9'-0"10": 6'-0"12": 4'-0"

2. Steel (Std. Weight or Heavier - Vapor Service):

   a. Maximum Spacing:

      1) 1/2" and under: 6'-0"
      2) 3/4" to 1": 8'-0"
      3) 1-1/4" and under: 9'-0"
      4) 1-1/2": 10'-0"
      5) 2" & larger: 10'-0"
      6) 3": 12'-0"
      7) 4" through 8": 12'-0"
      8) 10": 9'-0"
      9) 12": 6'-0"

3. Hard Drawn Copper & Brass (Liquid Service):

   a. Maximum Spacing:

      1) 3/4" & under: 5'-0"
      2) 1": 6'-0"
      3) 1-1/4": 6'-0"
      4) 1-1/2": 6'-0"
      5) 2": 8'-0"
      6) 2-1/2": 9'-0"
      7) 3": 10'-0"
      8) 4": 10'-0"
      9) 6": 10'-0"

4. Hard Drawn Copper & Brass (Vapor Service):

   a. Maximum Spacing:

      1) 3/4" & under: 6'-0"
      2) 1": 6'-0"
      3) 1-1/4": 6'-0"
      4) 1-1/2": 6'-0"
      5) 2": 10'-0"
      6) 2-1/2" & larger: 10'-0"

5. Plastic Pipe:

   a. Hangers shall be spaced based on the piping system manufacturer's instructions or, if no system instructions are available, space hangers at 4'-0" maximum centers.

6. Ultra-Flexible Pipe, Flexible Hose, and Soft Copper Tubing:

   a. Continuous channel with hangers maximum 8'-0" OC.

K. Installation of hangers shall conform to MSS SP-58, 69, and 89.

END OF SECTION 23 05 29

SECTION 23 05 30 - ROOF SUPPORT AND WIND BRACING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Wind Restraint of Rooftop Equipment

B. Rooftop Access and Service Platforms

C. Rooftop Duct Support

1.2 QUALITY ASSURANCE

A. General:

1. The Contractor shall retain a specialty consultant or equipment manufacturer to develop a wind restraint and support system and perform wind restraint calculations in accordance with these specifications, state, and local codes.
2. These requirements are beyond those listed in Section 23 05 50 of these specifications. Where a conflict arises between the wind restraint of this section and any other section, the Architect/Engineer shall be immediately notified for direction to proceed.

B. Manufacturer:

1. System Supports/Restraints: Company specializing in the manufacture of products specified in this section.
2. Equipment: Each company providing equipment that must meet wind restraint requirements shall provide certification included in project submittals that the equipment supplied for the project meets or exceeds the wind restraint of the project.

C. Installer: Installed by Contractor.

1.3 REFERENCES

A. International Building Code 2018

B. Technical Manual 5-809-10, NAVFAC P-355, Air Force Manual 88-3, Chapter 13

C. ASCE 7-10, Chapter 29

D. ASCE 7-16, Chapter 29

1.4 SUBMITTALS

A. Submit under provisions of Section 23 05 00.

B. Shop Drawings:

1. Calculations, restraint selections, and installation details shall be designed and sealed by a Professional Engineer licensed in the state where the project is located and experienced in wind restraint design and installation.

2. Coordination Drawings: Plans and sections drawn to scale, coordinating wind restraint bracing of mechanical components with other systems and equipment in the vicinity, including other wind restraint restraints.
3. Manufacturer's Certifications: Professional Engineer licensed in the state where the project is located shall review and approve manufacturer's certifications of compliance.
4. System Supports/Restraints - Submit for each condition requiring wind restraint bracing:
   a. Calculations for each wind restraint brace and detail used on the project.
   b. Plan drawings showing locations and types of wind restraint braces on contractor fabrication/installation drawings.
   c. Cross-reference between details and plan drawings to indicate exactly which brace is being installed at each location. Details provided are to clearly indicate attachments to structure, correctly representing the fastening requirements of bracing.
   d. Clear indication of brace design forces and maximum potential component forces at attachment points to building structure for confirmation of acceptability by the Structural Engineer of Record.
5. Equipment - Submit for each piece of equipment supplied:
   a. Certification that the equipment supplied for the project meets or exceeds the wind restraint requirements specified.
   b. Specific details of wind restraint design features of equipment and maximum wind restraint loads imparted to the structural support.
   c. Engineering calculations and details for equipment anchorage and support structure.

C. A wind restraint designer shall be provided whether or not exceptions listed in the applicable building code are met. If wind restraint restraints are not provided for a system that requires wind restraint bracing, the wind restraint designer shall submit a signed and sealed letter to the Architect/Engineer and Authorities Having Jurisdiction stating the exceptions, along with code reference, used for each item. Wind restraint designer shall review system installation for general conformance to the exception requirements stated in the code and document, in writing, the system has been installed in accordance with the exception.

1.5 TESTING AND INSPECTION

1.6 DELIVERY, STORAGE AND HANDLING

A. Deliver, store, protect and handle products to site. Accept material on site in factory containers and packing. Inspect for damage. Protect from damage and contamination by maintaining factory packaging until installation. Follow manufacturer's instructions for storage.

1.7 DESIGN REQUIREMENTS

A. This project is subject to the wind loading requirements of the International Building Code 2018 edition.

B. The total height of the structure and the height of the system to be restrained within the structure shall be determined in coordination with architectural plans and the General Contractor.

1.8 COORDINATION

A. Coordinate layout and installation of anchoring with building structural systems and architectural features, and with mechanical, fire-protection, electrical and other building features in the vicinity.

1.9 WARRANTY

A. Provide one-year warranty on parts and labor for manufacturer defects and installation workmanship.

PART 2 - PRODUCTS

2.1 SUPPLIERS

A. Miro Industries

B. Unistrut

2.2 DESIGN CRITERIA

A. The following design criteria applies to all equipment noted below.

B. General Information:

1. Adopted Building Code: IBC 2018
2. Building Occupancy Risk Category: II

C. Wind Design Criteria:

1. Mean Roof Height: 50 feet
2. Basic Wind Speed: 107 MPH @ 3-second gust
3. Exposure Category: B

D. Seismic:

1. Refer to Section 23 05 50 "Seismic Requirements for Equipment And Supports" for additional seismic requirements.

2.3 ACCESS AND SERVICE STAIRS AND PLATFORMS

A. Provide prefabricated OSHA 1910 compliant structure over obstructions and access to equipment installed on the roof as shown on the drawings. Supports include stanchioned supports anchored to the roof structure. Refer to drawings for stairs and/or service platform size, layout, and roofing material.

B. Roof equipment support manufacturer shall provide ASCE-7 code-compliant sealed submittal to support and restrain access and service stair and platforms for uplift and lateral loading.

C. Frame and Railing: Support frame and platform shall be stainless steel minimum 12-gauge channel or tube steel. Manufacturer shall determine final design.

D. Decking: Support decking shall be minimum 1" thick, non-slip stainless steel bar grating.

E. Minimum clear height above obstructions shall be 24 inches.

F. Acceptable Manufacturer:

1. Miro Industries Stanchioned Crossover Stairs

2.4 ROOF DUCT SUPPORTS

A. Roof duct support manufacturer shall provide ASCE-7 code-compliant sealed submittal to support and restrain rooftop duct system for uplift and lateral loading.

B. Refer to drawings for duct size, layout, structural framing, roofing material, and wind and seismic loading information.

C. Provide adjustable pre-fabricated roof duct supports for all duct installed on the roof. Supports include a combination of non-penetrating pillow block duct supports and stanchioned supports anchored to the roof structure.

D. Supports shall be constructed from stainless steel minimum 12-gauge channel or tube steel. Manufacturer shall determine final design.

E. Pillow block base shall be UV resistant polycarbonate rounded to prevent damage to the roof, and drainage holes shall prevent ponding of water in the support.

F. Acceptable Manufacturer:

1. Miro Industries DS and Stanchioned DS

PART 3 - EXECUTION

3.1 GENERAL

A. Install all items per manufacturer's instructions.

B. All wind restraint systems shall be installed in strict accordance with the manufacturer's written instructions and all certified submittal data.

C. Installation of wind restraints shall not cause any change in position of equipment, piping, or ductwork resulting in stresses or misalignment.

D. Prior to installation, bring to the Architect/Engineer's attention any discrepancies between the specifications and the field conditions, or changes required due to specific equipment selection.

E. Bracing may occur from flanges of structural beams, upper truss cords of bar joists, cast-in-place inserts.

F. Cable restraints shall be installed slightly slack to avoid short-circuiting the isolated suspended equipment, ductwork, piping, or conduit. Cable assemblies shall be installed taut on non-isolated systems. Solid braces may be used in place of cables on rigidly attached systems only. Do not install cables over sharp corners.

G. Provide reinforced clevis bolts when required.

H. The vibration isolation manufacturer shall furnish integral structural steel bases as required. Independent steel rails are not acceptable.

I. Piping crossing building seismic or expansion joints, passing from building to building, or supported from different portions of the building shall be installed to allow differential support displacements without damaging the pipe, equipment connections, or support connections. Pipe offsets, loops, anchors, and guides shall be installed as required to provide required motion capability and limit motion of adjacent piping.

J. Positively attach all roof-mounted equipment to roof curbs. Positively attach all roof curbs to building structure.

K. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc rich primer to welding.

L. Supports shall extend directly to building structure.

M. Furnish, install and prime all auxiliary structural steel for support of piping systems that are not shown on the drawings as being by others.

N. Install hangers and supports complete with lock nuts, clamps, rods, bolts, couplings, swivels, inserts and required accessories.

O. Roof Supports: Install per manufacturer's requirements. Coordinate with Roofing Contractor.

3.2 INSPECTION

A. Special inspection and testing shall be done in accordance with Chapter 17 of the International Building Code.

B. The Owner shall employ a Special Inspection Agency to perform the duties and responsibilities specified in Section 1704 and 1705.

C. Work performed on the premises of a fabricator approved by the building official need not be tested and inspected. The fabricator shall submit a certificate of compliance that the work has been performed in accordance with the approved plans and specifications to the building official and the Architect and Engineer of Record.

D. The Special Inspection Agency shall furnish inspection reports to the building official, the Owner, the Architect, the Engineer of Record, and the General Contractor. The reports shall be completed and furnished within 48 hours of inspected work. A final signed report stating whether the work requiring special inspection was, to the best of the Special Inspection Agency's knowledge, in conformance with the approved plans and specifications shall be submitted.

END OF SECTION 23 05 30

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SECTION 23 05 48 - HVAC VIBRATION ISOLATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Bases.

B. Vibration Isolation.

C. Flexible Connectors.

1.2 SUBMITTALS

A. Submit shop drawings per Section 23 05 00 and the Vibration Isolation Submittal Form at the end of this section.

B. Vibration isolation submittals may be included with equipment being isolated, but must comply with this section.

C. Base submittals shall include equipment served, construction, coatings, weights, and dimensions.

D. Isolator submittals shall include:

1. Equipment served
2. Type of Isolator
3. Load in Pounds per Isolator
4. Recommended Maximum Load for Isolator
5. Spring Constants of Isolators (for Spring Isolators)
6. Load vs. Deflection Curves (for Neoprene Isolators)
7. Specified Deflection
8. Deflection to Solid (at least 150% of calculated deflection)
9. Loaded (Operating) Deflection
10. Free Height
11. Loaded Height
12. Kx/Ky (horizontal to vertical stiffness ratio - for spring isolators)
13. Materials and Coatings
14. Spring Diameters

E. Make separate calculations for each isolator on equipment where the load is not equally distributed.

F. Flexible connector shop drawings shall include overall face-to-face length and all specified properties.

G. Submit certification that equipment, accessories, and components will withstand seismic forces defined in Section 23 05 50. Include the following:

1. Basis for Certification: Indicate whether certification is based on actual test of assembled components or on calculation.

    a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

PART 2 - PRODUCTS

2.1 BASIC CONSTRUCTION AND REQUIREMENT

A. Vibration isolation for this project is subject to seismic restraint requirements of Section 23 05 50.

B. Vibration isolators shall have either known undeflected heights or other markings so deflection under load can be verified.

C. All isolators shall operate in the linear portion of their load versus deflection curve. The linear portion of the deflection curve of all spring isolators shall extend 50% beyond the calculated operating deflection (e.g., 3" for 2" calculated deflection). The point of 50% additional deflection shall not exceed the recommended load rating of the isolator.

D. The lateral to vertical stiffness ratio (Kx/Ky) of spring isolators shall be between 0.8 and 2.0.

E. All neoprene shall have UV resistance sufficient for 20 years of outdoor service.

F. All isolators shall be designed or treated for corrosion resistance. Steel bases shall be cleaned of welding slag and primed for interior use, and hot dip galvanized after fabrication for exterior use. All bolts and washers over 3/8" diameter located outdoors shall be hot dip galvanized per ASTM A153. All other bolts, nuts and washers shall be zinc electroplated. All ferrous portions of isolators, other than springs, for exterior use shall be hot dip galvanized after fabrication. Outdoor springs shall be neoprene dipped or hot dip galvanized. All damage to coatings shall be field repaired with two coats of zinc rich coating.

G. Equip all mountings used with structural steel bases with height-saving brackets. Bottoms of the brackets shall be 1-1/2" to 2-1/2" above the floor or housekeeping pad, unless shown otherwise on the drawings. Steel bases shall have at least four points of support.

H. Provide motor slide rails for belt-driven equipment per Section 23 05 13.

I. All isolators, except M1, shall have provision for leveling.

2.2 MOUNTINGS

A. Type M3:

1. Free standing, laterally stable spring isolators without housings and complete with 1/4" neoprene friction pads.
2. Units shall have bolt holes but need not be bolted down unless called for or needed to prevent movement. If bolted down, prevent short circuiting with neoprene bushings and washers between bolts and isolators. Bolt holes shall not be within the springs.
3. All mountings shall have leveling bolts.
4. Manufacturers:

    a. Mason "SLFH"
    b. Kinetics "FDS"
    c. Amber/Booth SW-3 4"
    d. Vibration Eliminator Co. "OST"

2.3 HANGERS

A. Type H2:

1. Vibration hangers shall contain a steel spring in a neoprene cup with a grommet to prevent short circuiting the hanger rod.
2. The cup shall have a steel washer to distribute load on the neoprene and prevent its extrusion.
3. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30° arc before contacting the grommet and short circuiting the spring.
4. Provide end connections for hanging ductwork or piping.
5. Manufacturers:

    a. Mason "30"
    b. Kinetics "SRH"
    c. Amber/Booth "BSRA"
    d. Aeroflex "RSH"
    e. Vibration Eliminator Co. "SNC"
    f. Vibro Acoustics "SH/SHC"

B. Type H3:

1. Vibration hangers shall have a steel spring in a neoprene cup with a grommet to prevent short circuiting of the hanger rod.
2. The cup shall have a steel washer to distribute load on the neoprene and prevent its extrusion.
3. Spring diameters and hanger box lower hole sizes shall be large enough to permit the hanger rod to swing through a 30° arc before contacting the grommet and short circuiting the spring.
4. Provide end connections for hanging ductwork or piping.
5. Hangers shall be capable of holding the load at a fixed elevation during installation. They shall have a secondary adjustment to transfer the load to the spring and maintain the same position.
6. Deflection shall be indicated by a pointer and scale.
7. Manufacturer:

    a. Mason "30N"
    b. Kinetics "SFH"
    c. Amber/Booth "BSW"
    d. Vibration Eliminator Co. "SNRC"
    e. Vibro Acoustics "SHR"

2.4 BASES

A. Type B3:

1. Rectangular structural channel concrete forms for floating foundations.
2. Where applicable, bases shall be large enough to support suction elbows, discharge elbows, and suction diffusers.
3. Channel depth shall be at least 1/12 the longest dimension of the base but not less than 6". Depth need not exceed 12" if rigidity is acceptable to equipment manufacturer.
4. Forms shall include 1/2" rebars welded on 6" centers running both ways in a layer 1-1/2" above the bottom, and drilled steel members with sleeves welded below the holes to receive the equipment anchor bolts.
5. Contractor shall pour 3,300 PSI concrete inside entire base. Concrete to be same thickness as sides of base. Trowel concrete smooth on top of base.
6. Use height saving brackets, unless noted otherwise.
7. Manufacturers:

    a. Mason "K"
    b. Kinetics "CIB-H"
    c. Aeroflex "MPF"
    d. Amber Booth "CPF"
    e. Bulldog, Inc.
    f. Vibration Eliminator Co. "SN".

2.5 FLEXIBLE CONNECTORS (NOISE AND VIBRATION ELIMINATORS)

A. Type FC1:

1. Spherical flexible connectors with multiple plies of nylon tire cord fabric and either EPDM or molded and cured neoprene. Outdoor units shall be EPDM.
2. Steel aircraft cables or threaded steel rods shall be used to prevent excess elongation.
3. All straight through connections shall be made with twin-spheres properly pre-extended as recommended by the manufacturer.
4. Connectors up to 2" size may have threaded ends.
5. Connectors 2-1/2" and over shall have floating steel flanges recessed to lock raised face neoprene flanges.
6. All connectors shall be rated for a minimum working pressure of 150 psi at 200°F.
7. Manufacturer:

   a. Metraflex "Double Cable-Sphere"
   b. Minnesota Flex Corp.
   c. Mercer "200 Series"
   d. Twin City Hose "MS2".

2.6 VIBRATION ISOLATION CURBS

A. Spring Isolated Curbs:

1. Provide factory fabricated vibration isolated curb consisting of an upper floating section resting on a rigid rectangular steel tube structure containing adjustable steel vibration isolation springs.
2. Roof Mounting Curb: Curb height as shown on drawings, minimum 14 gauge galvanized steel, one-piece construction, insulated, all welded, wood nailer.
3. Vibration Isolation:

   a. Isolators shall consist of free standing, unhoused laterally stable steel springs.
   b. Springs shall be zinc electroplated.
   c. Springs shall rest on a minimum of 1/4” neoprene pad.
   d. Springs shall provide a minimum of 1-1/2” deflection calculated based on final assembled loads.

4. Provide continuous wood nailing strip and counter flashing along entire perimeter of the curb.
5. Provide continuous air and water seal, such as an EPDM bellows, around the entire curb.
6. Curb assembly shall withstand 125#/sf lateral wind loading against the supported equipment.
7. The curb shall be designed with lateral restraint to meet seismic requirements specified in Section 23 05 50.
8. Coordinate internal structural cross framing with ductwork and piping routed in the curb.
9. Manufacturers:

   a. Mason Industries, Inc. - Type RSC
   b. Vibration Elimination Company - BERC
   c. ThyCurb - Vibro Curb II
   d. Kinetics - SSR.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION

A. Install all products per manufacturer's recommendations.

B. Provide vibration isolation as indicated on the drawings and as described herein.

C. Clean the surface below all mountings that are not bolted down and apply adhesive cement equal to Mason Type WG between mounting and floor. If movement occurs, bolt mountings down. Isolate bolts from baseplates with neoprene washers and bushings.

D. All static deflections listed in the drawings and specifications are the minimum acceptable actual deflection of the isolator under the weight of the installed equipment - not the maximum rated deflection of the isolator.

E. Support equipment to be mounted on structural steel frames with isolators under the frames or under brackets welded to the frames. Where frames are not needed, fasten isolators directly to the equipment.

F. Where a specific quantity of hangers is noted in these specifications, it shall mean hanger pairs for support points that require multiple hangers, such as rectangular ducts or pipes supported on a strut rack.

3.2 PIPE ISOLATION

A. The first five hangers from vibration-isolated equipment shall have spring isolators with the same static deflection as the equipment. Use type H1 or H2 as required for the specified deflection. The next five hangers shall be type H1.

B. For base mounted pumps without resilient mountings, the first five hangers shall be Type H1.

C. Where piping is floor-supported, use M2 instead of H1 and M3 instead of H2.

D. Install flexible connectors in all piping connected to vibration producing equipment. This includes all fans, base-mounted pumps, compressors, etc. Absence of flexible connectors on piping diagrams <u>does not</u> imply that they are not required.

E. Use Type FC1 where pressures are lower than 150 psi, temperatures are below 220°F , and the fluid handled is compatible with neoprene and EPDM.

F. Use Type FC2 for all other services. FC2 shall be installed parallel with equipment shafts.

G. Provide sufficient piping flexibility for vibrating refrigerant equipment, or furnish flexible connectors with appropriate temperature and pressure ratings.

H. Vibration isolators shall not cause any change in position of piping that will result in stresses in connections or misalignment of shafts or bearings. Equipment and piping shall be maintained in a rigid position during installation. Do not transfer load to the isolators until the installation is complete and under full operational load. Hanger H3 and Mounting M4 may be used instead of other products for this purpose.

I. Support piping to prevent extension of flexible connectors.

3.3 VIBRATION ISOLATION OF DUCTWORK

A. The first three hangers on all fan systems with static pressure greater than 1.0" shall be Type H2 with 0.75" minimum static deflection. All other hangers supporting ductwork within 50' of and connected to vibration-isolated equipment shall be Type H1 with at least 0.20".

B. Provide flexible duct connections as described in Section 23 33 00 at all fan inlets and outlets and on the mechanical room side of all locations where ducts penetrate mechanical room walls.

3.4 VIBRATION ISOLATION SCHEDULE

A. Inline Pumps:

1. Base Type: NA
2. Isolator Type: M3 or H2 or H3
3. Static Deflection :0.75"
4. Flexible Connections: NA

B. Base-Mounted Pumps:

1. Base Type: B3
2. Isolator Type: M3
3. Static Deflection: 0.75"
4. Flexible Connections: FC-1

END OF SECTION 23 05 48

VIBRATION ISOLATION SUBMITTAL FORM

COLUMN 1	2	3	4	5	6	7	8	9	10	11	12
		PROPOSED ISOLATOR							CALCULATIONS		
ITEM SERVED	MIN DEFL (")	TAG	MODEL	MAX LOAD (#)	DEFL @ MAX LOAD (")	DEFL TO SOLID (")	FREE HT (")	Kx/Ky	LOAD (#)	DEFL (")	DEFL RATIO

COLUMN NOTES: Note numbers correspond to the column numbers above.
1. Item served should match designation on the design drawings.
2. List the deflection scheduled or specified in the design documents.
3. List the designation for this isolator. This is most useful when one item has multiple different isolators to support its weight.
4. List the manufacturer's complete model designation for the isolator.
5. List the manufacturer's maximum rated load for the isolator.
6. List the isolator deflection at the maximum rated load in column 5.
7. For spring isolators list the deflection when the springs are solid. This is not normally the same entry as in column 6.
8. List the height of the isolator when unloaded. Shop drawings must show where this is measured.
9. List the rated horizontal to vertical stiffness ratio. This must be between 0.8 and 2.0.
10. List the calculated equipment load on each isolator. For items with unequal weight distribution, calculate each isolator separately.
11. List the calculated deflection under the calculated load. For springs this will be column 10*(column 6 / column 5).
12. List the answer from dividing column 7 by column 11. This must be at least 1.5. If not, select an isolator with more nominal deflection.

GENERAL NOTES:
1. When submitting hangers or supports for a weight range, fill in two rows - one for the maximum and one for the minimum weight.

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SECTION 23 05 50 - SEISMIC REQUIREMENTS FOR EQUIPMENT AND SUPPORTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Seismic Requirements.

1.2 QUALITY ASSURANCE

A. General:

1. The contractor shall retain a specialty consultant or equipment manufacturer to develop a seismic restraint and support system and perform seismic calculations in accordance with these specifications, state, and local codes.
2. Items used for seismic restraint of equipment and systems shall be specifically manufactured for seismic restraint.
3. These requirements are beyond those listed in Section 23 05 29 of these specifications. Where a conflict arises between the seismic requirements of this section and any other section, the Architect/Engineer shall be immediately notified for direction to proceed.

B. Manufacturer:

1. System Supports/Restraints: Company specializing in the manufacture of products specified in this Section.
2. Equipment: Each company providing equipment that must meet seismic requirements shall provide certification included in project submittals the equipment supplied for the project meets or exceeds the seismic requirements of the project.

C. Testing Agency: An independent testing agency, acceptable to Authorities Having Jurisdiction, with experience and capability to conduct the testing indicated.

D. Installer: Company specializing in performing the work of this Section.

1.3 SUBMITTALS

A. Submit under provisions of Section 23 05 00.

B. Shop Drawings:

1. Calculations, restraint selections, and installation details shall be designed and sealed by a Professional Engineer licensed in the state where the project is located experienced in seismic restraint design and installation.
2. Coordination Drawings: Plans and sections drawn to scale, coordinating seismic bracing of mechanical components with other systems and equipment in the vicinity, including other seismic restraints.
3. Manufacturer's Certifications: Professional Engineer licensed in the state where the project is located shall review and approve manufacturer's certifications of compliance.
4. System Supports/Restraints - Submit for each condition requiring seismic bracing:
    a. Calculations for each seismic brace and detail utilized on the project.
    b. Plan drawings showing locations and types of seismic braces on contractor fabrication/installation drawings.

c. Cross-reference between details and plan drawings to indicate exactly which brace is being installed at each location. Details provided are to clearly indicate attachments to structure, correctly representing the fastening requirements of bracing.
d. Clear indication of brace design forces and maximum potential component forces at attachment points to building structure for confirmation of acceptability by the Structural Engineer of Record.

5. Equipment - Submit for each piece of equipment supplied:

a. Certification that the equipment supplied for the project meets or exceeds the seismic requirements specified.
b. Specific details of seismic design features of equipment and maximum seismic loads imparted to the structural support.
c. Engineering calculations and details for equipment anchorage and support structure.

C. A seismic restraint designer shall be provided whether or not exceptions listed in the applicable building code are met. If seismic restraints are not provided for a system that requires seismic bracing, the seismic designer shall submit a signed and sealed letter to the Architect/Engineer and Authorities Having Jurisdiction stating the exceptions, along with code reference, utilized for each item. Seismic designer shall review system installation for general conformance to the exception requirements stated in the code and document, in writing, the system has been installed in accordance to the exception.

1.4 TESTING AND INSPECTION

A. Special Inspection and Testing shall be done in accordance with Chapter 17 of the Building Code.

B. The Owner shall employ a Special Inspection Agency to perform the duties and responsibilities specified in Section 1704 and 1705.

C. Work performed on the premises of a fabricator approved by the building official need not be tested and inspected. The fabricator shall submit a certificate of compliance that the work has been performed in accordance with the approved plans and specifications to the building official and the Architect and Engineer of Record.

D. The Special Inspection Agency shall furnish inspection reports to the building official, the Owner, the Architect, the Engineer of Record, and the General Contractor. The reports shall be completed and furnished within 48 hours of inspected work. A final signed report stating whether the work requiring special inspection was, to the best of the Special Inspection Agency's knowledge, in conformance with the approved plans and specifications shall be submitted.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site. Accept material on site in factory containers and packing. Inspect for damage. Protect from damage and contamination by maintaining factory packaging until installation. Follow manufacturer's instructions for storage.

1.6 DESIGN REQUIREMENTS

A. This project is subject to the seismic bracing requirements of the International Building Code, 2012 edition.

B. The following criteria are applicable to this project:

1. Risk Category: II
2. Seismic Importance Factor: I_E = 1.0Seismic Design Category: C

3. Component Amplification Factors (ap) and Component Response Modification Factors (Rp) shall be taken from Table 13.5-1 in ASCE 7-10 for the individual equipment or system being restrained.
4. Component Importance Factors (Ip) shall be taken from Section 13.1.3 in ASCE 7-10 for the individual equipment or system being restrained.
5. The total height of the structure and the height of the system to be restrained within the structure shall be determined in coordination with architectural plans and the General Contractor.

C. Forces shall be calculated with the above requirements and Equation 13.3-1, -2, and -3 of ASCE 7-10, unless exempted by 13.1.4. Equipment shall meet International Building Code and ASCE 7 seismic qualification requirements in concurrence with ICC ES AC156 Acceptance Criteria for Seismic Qualification by Shake-Table Testing of Nonstructural Components and Systems.

D. All seismic anchorage and bracing shall comply with the St. Louis County Rules & Regulations on Anchorage & Sway Bracing - Mechanical, Electrical & Plumbing (MEP) System Components.

E. All seismic anchorage and bracing shall comply with FM Global Property Loss Prevention Data Sheet 1-11, Fire Following Earthquakes.

1.7 COORDINATION

A. Coordinate layout and installation of seismic bracing with building structural systems and architectural features, and with mechanical, fire-protection, electrical and other building features in the vicinity.

B. Coordinate concrete bases with building structural system.

1.8 WARRANTY

A. Provide one-year warranty on parts and labor for manufacturer defects and installation workmanship.

PART 2 - PRODUCTS

2.1 SUPPLIERS

A. Following is a partial list of manufacturer/supplier contact information for seismic restraints:

1. B-Line Systems, Inc. (800) 851-7415, www.b-line.com.
2. Unistrut Corporation http://www.unistrut.us/
3. Kinetics Noise Control (877) 457-2695, www.kineticsnoise.com.
4. Mason Industries, Inc. www.mason-ind.com.
5. Loos & Co., Inc. (800) 321-5667, www.loosnaples.com.
6. Tolco (909) 737-5599, www.tolco.com
7. ISAT 877.523.6060, www.isatsb.com
8. Vibro-Acoustics (416) 291-7371, https://virs.vibro-acoustics.com/

2.2 SEISMIC DESIGN CRITERIA

A. This section describes the requirements for seismic restraint of systems and equipment related to continued operation of the facility after a design seismic event.

B. Definitions

1. Stay in Place:

a. All systems and equipment shall be anchored and restrained such that the anchoring system is intended not to fail and equipment and/or system components will not fall.

2. Remain Operational:

a. Requirements for "Stay in Place" listed above shall be met.
b. The following systems and associated equipment are intended not to fail externally or internally and are intended to remain operational.

1) Fire Protection
2) Plumbing
3) Medical Gas
4) Heating
5) Cooling
6) Humidification
7) Air Handling
8) Exhaust
9) Dust Collection

2.3 SEISMIC BRACING AND SUPPORT OF SYSTEMS AND COMPONENTS

A. General:

1. Seismic restraint designer shall coordinate all attachments with the Structural Engineer of Record; refer to submittal requirements.
2. The seismic restraint design shall be based on actual equipment data obtained from manufacturer's submittals or the manufacturer. The equipment manufacturer shall verify and provide written certification the attachment points on the equipment can accept the combination of seismic, weight, and other imposed loads.
3. Design analysis shall include calculated dead loads, static seismic loads, and capacity of materials utilized for the connection of the equipment or system to the structure.
4. Analysis shall detail anchoring methods, bolt diameter, embedment, and weld length.
5. All seismic restraint devices shall be designed to accept without failure the forces calculated per the applicable building code.
6. All seismic restraints and combination isolator/restraints shall have verification of their seismic capabilities witnessed by an independent testing agency.

B. Friction from gravity loads shall not be considered resistance to seismic forces.

C. Fire protection systems shall meet the requirements of NFPA-13 and NFPA-14 for the building seismic requirements.

D. Housekeeping Pads:

1. Reinforced housekeeping pads shall be provided to handle shear, tension, and compression forces with proper reinforcement, doweling, and attachments connecting the pad to the structural slab.

2.4 SEISMIC RESTRAINT AND CONSTRUCTION OF EQUIPMENT

A. Equipment supplied for the project shall be designed to meet the requirements of lateral forces calculated using the applicable code and method described above.

B. The following is a partial list of equipment that shall be restrained and that shall be constructed to meet seismic forces described in this section:

1. Air Compressors
2. Pumps
3. Tanks
4. Fire Protection Equipment
5. Fire Pumps

2.5 MATERIALS

A. Use the following materials for restraints:

1. Indoor Dry Locations: Steel, zinc plated.
2. Outdoors and Damp Locations: Galvanized steel.
3. Corrosive Locations: Stainless steel.

2.6 ANCHORAGE AND STRUCTURAL ATTACHMENT COMPONENTS

A. Strength: Defined in reports by ICC Evaluation Service or another agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Strength in tension and shear of components used shall be at least two times the maximum seismic forces to which they will be subjected.

B. Concrete and Masonry Anchor Bolts and Studs: Steel-expansion wedge type. Comply with IBC, ACI and ICC ES requirements for cracked concrete anchors.

C. Concrete Inserts: Steel-channel type.

D. Through Bolts: Structural type, hex head, high strength. Comply with ASTM F3125, Grade A 325.

E. Welding Lugs: Comply with MSS SP-69, Type 57.

F. Beam Clamps for Steel Beams and Joists: Double sided. Single-sided type is not acceptable.

G. Bushings for Floor-Mounted Equipment Anchors: Neoprene units designed for seismically rated rigid equipment mountings, and matched to the type and size of anchor bolts and studs used.

H. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for seismically rated rigid equipment mountings, and matched to the type and size of attachment devices used.

2.7 SEISMIC BRACING COMPONENTS

A. Slotted Steel Channel: 1-5/8-by-1-5/8-inch cross section, formed from 0.1046-inch-thick steel, with 9/16-by-7/8-inch slots at a maximum of 2 inches o.c. in webs, and flange edges turned toward web.

1. Materials for Channel: ASTM A 1011, GR 33.
2. Materials for Fittings and Accessories: ASTM A 635, ASTM A 576, or ASTM A 36.
3. Fittings and Accessories: Products of the same manufacturer as channels and designed for use with that product.
4. Finish: Baked, rust-inhibiting, acrylic-enamel paint applied after cleaning and phosphate treatment, unless otherwise indicated.

B. Channel-Type Bracing Assemblies: Slotted steel channel, with adjustable hinged steel brackets and bolts.

C. Cable-Type Bracing Assemblies: Zinc-coated, high-strength steel wire rope cable attached to steel thimbles, brackets, and bolts designed for cable service.

1. Arrange units for attachment to the braced component at one end and to the structure at the other end.
2. Wire Rope Cable: Comply with ASTM A 603. Use 49- or 133-strand cable with a minimum strength of 2 times the calculated maximum seismic force to be resisted.

D. Hanger Rod Stiffeners: Slotted steel channels with internally bolted connections to hanger rod.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer to the applicable code sections and Authority Having Jurisdiction for the exact seismic restraint requirements of piping, ductwork, conduit, equipment, etc.

B. Layout of transverse and longitudinal bracing shall follow recommendations of approved design standards listed in Part 1 of this specification section.

C. All rigid floor mounted equipment shall have a resilient media between the equipment mounting hole and the anchor bolt in concrete.

D. All seismic restraint systems shall be installed in strict accordance with the manufacturer's written instructions and all certified submittal data.

E. Installation of seismic restraints shall not cause any change in position of equipment, piping, or ductwork, resulting in stresses or misalignment.

F. No rigid connections between equipment and the building structure shall be made that degrade the noise and vibration-isolation system specified.

G. Do not install any equipment, piping, duct, or conduit that makes rigid connections with the building unless isolation is not specified.

H. Coordinate work with all other trades to avoid rigid contact with the building. Any conflicts with other trades that will result in rigid contact with equipment or piping due to inadequate space or other unforeseen conditions shall be brought to the Architect/Engineer's attention prior to specific equipment selection.

I. Prior to installation, bring to the Architect/Engineer's attention any discrepancies between the specifications and the field conditions, or changes required due to specific equipment selection.

J. Bracing may occur from flanges of structural beams, upper truss cords of bar joists, cast in place inserts, or International Code Council approved seismic anchors for installation in concrete.

K. Cable restraints shall be installed slightly slack to avoid short-circuiting the isolated suspended equipment, ductwork, piping, or conduit.

L. Cable assemblies shall be installed taut on non-isolated systems. Solid braces may be used in place of cables on rigidly attached systems only.

M. Do not install cables over sharp corners.

N. Brace support rods when necessary to accept compressive loads. Welding of compression braces to the vertical support rods is not acceptable.

O. Provide reinforced clevis bolts when required.

P. The vibration isolation manufacturer shall furnish integral structural steel bases as required. Independent steel rails are not acceptable.

Q. Post-Installed anchors shall be provided to meet seismic requirements.

R. Vertical pipe risers flexibly supported to accommodate thermal motion and/or pipe vibration shall be guided to maintain pipe stability and provide horizontal seismic restraint.

S. Seismic restraints shall be mechanically attached to the system. Looping restraints around the system is not acceptable.

T. Piping crossing building seismic or expansion joints, passing from building to building, or supported from different portions of the building shall be installed to allow differential support displacements without damaging the pipe, equipment connections, or support connections. Pipe offsets, loops, anchors, and guides shall be installed as required to provide required motion capability and limit motion of adjacent piping.

U. Water tanks shall be secured to their saddles by welding or proper concrete attachment, and those saddles shall be properly attached to the structure.

V. Brace all terminal units with water coils as required by the building code and provide flexible connection to the coil if bracing is required.

W. Independently brace duct mounted equipment (terminal units, in-line fans, etc.) and the associated suspended ductwork.

X. Do not brace a system to two different structures such as a wall and a ceiling.

Y. Provide appropriately sized openings in walls, floors, and ceilings for anticipated seismic movement. Provide fire seal systems in fire-rated walls.

Z. Positively attach all roof mounted equipment to roof curbs. Positively attach all roof curbs to building structure.

AA. Exposed seismic supports in occupied areas shall be guarded or covered to protect occupants.

BB. Coordinate seismic bracing of architecturally exposed ductwork with the Architect/Engineer.

3.2 SEISMIC RESTRAINT EXCLUSIONS

A. Refer to the applicable code sections and Authority Having Jurisdiction for allowable exclusions.

END OF SECTION 23 05 50

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SECTION 23 05 53 - HVAC IDENTIFICATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Identification of products installed under Division 23.

1.2 SUBMITTALS

A. Submit shop drawings under provisions of Section 23 05 00. Include list of items identified, wording, letter sizes, and color coding.

B. Include valve chart and schedule listing valve tag number, location, function, and valve manufacturer's name and model number.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. 3M

B. Bunting

C. Calpico

D. Craftmark

E. Emedco

F. Kolbi Industries

G. Seton

H. W.H. Brady

I. Marking Services.

2.2 MATERIALS

A. All pipe markers (purchased or stenciled) shall conform to ANSI A13.1. Marker lengths and letter sizes shall be at least the following:

OD of Pipe or Insulation	Marker Length	Size of Letters
Up to and including 1-1/4" (32mm)	8" (200 mm)	1/2" (12 mm)
1-1/2" (40 mm) to 2" (50 mm)	8" (200 mm)	3/4" (20 mm)
2-1/2" (65 mm) to 6" (150 mm)	12" (300 mm)	1-1/4" (32 mm)
8" (200 mm) to 10" (250 mm)	24" (600 mm)	2-1/2" (65 mm)
Over 10" (250 mm)	32" (800 mm)	3-1/2" (90 mm)

Plastic tags may be used for outside diameters under 3/4" (20 mm)

B. Plastic Tags: Minimum 1-1/2" square or round laminated three-layer phenolic with engraved, 1/4" minimum black letters on light contrasting background.

C. Brass Tags: Brass background with engraved black letters. Tag size minimum 1-1/2" square or 1-1/2" round.

D. Plastic Pipe Markers: Semi-rigid plastic, preformed to fit around pipe or pipe covering; indicating flow direction and fluid conveyed.

E. Vinyl Pipe Markers: Colored vinyl with permanent pressure sensitive adhesive backing.

F. Stencil Painted Pipe Markers: Use industrial enamel spray paint per ANSI Standard A13.1. Indicate fluid conveyed and flow direction.

G. Underground Pipe Markers: Bright colored continuously printed plastic ribbon tape 6" wide by 3.5 mils thick, manufactured for direct burial, with aluminum foil core for location by non-ferric metal detectors and bold lettering identifying buried item.

H. Tracer Wire:

1. Single copper conductors shall be solid or stranded annealed or hard uncoated copper per UL83 and ASTM requirements. Tracer tape or copper-coated steel wire is not acceptable.
2. Conductor shall be insulated with HMWPE as specified and applied in a concentric manner. The minimum at any point shall not be less than 90% of the specified average thickness in compliance with UL 83.
3. Tracer wire shall be continuously spark tested at 7500 Volts DC. Other electrical and mechanical tests shall be in accordance with UL 1581.

I. Ductwork Markers:

1. Ductwork systems containing hazardous materials shall be provided with minimum 2" x 4" ANSI Z535.2 biohazard warning labels with custom labeling describing hazard. Refer to Part 3 for system and label description.
2. Vinyl Markers: Colored vinyl with permanent pressure sensitive adhesive backing suitable for indoor and outdoor application.

J. Maintenance Access Doors:

1. Doors and roof hatches used to access equipment serving hazardous ductwork systems shall be provided with a minimum 4" x 6" ANSI Z5353.2 biohazard warning label. Label shall read "WARNING - BIOHAZARD. ONLY AUTHORIZED PERSONNEL BEYOND THIS POINT".
2. Coordinate location of warning label with Owner.

K. Ceiling Markers:

1. Label Style:

a. The intent is for the ceiling labels to be inconspicuous but easy to find and read while standing underneath. The labels shall be located on the grid T-bar nearest the ceiling tile that can be removed to provide the best access to the serviceable side of equipment or to valves. An arrow can be used to point to the tile needing removal.
b. The label tape shall be approximately 1/2" wide with all capitalized letters approximately 3/16” tall.
c. Ceiling grid labels shall be made with a label maker with durable adhesive labels having a clear background and black letters.
d. Equipment labels shall be as designated on the drawings (e.g., FCU-606B, etc.).

e. Valve labels shall be designated by the size, service, and the valve tag number (e.g., 1-1/4" CW #123, 2" HWS #234, etc.). A single longer label can be used to identify multiple valves using spaces between the descriptors if the valves are located close together and have the same service (e.g., HWS and HWR valves serving the same equipment or CW, HW, and HWC lines serving the same restroom, etc.).

f. Fire, fire/smoke and smoke dampers shall be labeled consistent with the type (e.g., Fire Damper, Fire/Smoke Damper, etc.),

2. "Dot" Style:

a. The intent is for the ceiling labels to be inconspicuous but easy to find and read while standing underneath. The labels shall be located on the grid T-bar nearest the ceiling tile that can be removed to provide the best access to the serviceable side of equipment or to valves.

b. The marker shall be a self-adhesive color dot approximately 1/2" in diameter.

c. The equipment and accessories to be marked and dot color shall be coordinated with the Architect/Engineer and Owner.

1) Equipment and accessories to be marked:

a) Hydronic Valves
b) Fire Dampers
c) Fire/Smoke and Smoke Dampers
d) Fan Coil Units
e) Project Specific Item

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install all products per manufacturer's recommendations.

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

C. Valves:

1. All valves (except shutoff valves at equipment) shall have numbered tags.
2. Provide or replace numbered tags on all existing valves that are connected to new systems or that have been revised.
3. Provide all existing valves used to extend utilities to this project with numbered tags. Review tag numbering sequence with the Owner prior to ordering tags.
4. Secure tags with heavy duty key chain and brass "S" link or with mechanically fastened plastic straps.
5. Attach to handwheel or around valve stem. On lever operated valves, drill the lever to attach tags.
6. Number all tags and show the service of the pipe.
7. Provide one Plexiglas framed valve directory listing all valves, with respective tag numbers, uses and locations. Mount directory in location chosen by the Architect/Engineer.

D. Pipe Markers:

1. Adhesive Backed Markers: Use Brady Style 1, 2, or 3 on pipes 3" diameter and larger. Use Brady Style 4, 6, or 8 on pipes under 3" diameter. Similar styles by other listed manufacturers are acceptable. Secure all markers at both ends with a wrap of pressure sensitive tape completely around the pipe.
2. Snap-on Markers: Use Seton "Setmark" on pipes up to 5-7/8" OD. Use Seton "Setmark" with nylon or Velcro ties for pipes 6" OD and over. Similar styles by other listed manufacturers are acceptable.

3. Stencil Painted Pipe Markers:

    a. Remove rust, grease, dirt, and all foreign substances from the pipe surface.
    b. Apply primer on non-insulated pipes before painting.
    c. Use background and letter colors as scheduled later in this section.

4. Apply markers and arrows in the following locations where clearly visible:

    a. At each valve.
    b. On both sides of walls that pipes penetrate.
    c. At least every 20 feet along all pipes.
    d. On each riser and each leg of each "T" joint.
    e. At least once in every room and each story traversed.

5. Underground Pipe Markers: Install 8" to 10" below grade, directly above buried pipes.

E. Ductwork Markers:

1. Apply ductwork markers on ductwork systems containing hazardous materials in the following locations where clearly visible:

    a. On both sides of walls that ducts penetrate.
    b. At least every 20 feet along all ducts.
    c. On each riser and each leg of each branch connection.
    d. At least once in every room and each story traversed.
    e. At all ductwork access doors.
    f. At all fans and equipment serving ductwork system. Markers shall be clearly visible from the normal maintenance access path to the equipment. Coordinate placement location with Owner.

F. Equipment:

1. All equipment not easily identifiable such as controls, relays, gauges, etc.; and all equipment in an area remote from its function such as air handling units, exhaust fans, filters, reheat coils, dampers, etc.; shall have nameplates or plastic tags listing name, function, and drawing symbol. Do not label exposed equipment in public areas.
2. Fasten nameplates or plastic tags with stainless steel self-tapping screws or permanently bonding cement.
3. Mechanical equipment that is not covered by the U.S. National Appliance Energy Conservation Act (NAECA) of 1987 shall carry a permanent label installed by the manufacturer stating that the equipment complies with the requirements of ASHRAE 90.1.

G. Miscellaneous:

1. Attach self-adhesive vinyl labels at all duct access doors used to reset fusible links or actuators on fire, fire/smoke, or smoke dampers. Lettering shall be a minimum of 1/2" high. Labels shall indicate damper type.
2. Provide engraved plastic tags at all hydronic or steam system make-up water meters.

H. Tracer Wire:

1. Tracer wire shall be installed on top of all non-metallic buried utilities.
2. Tracer wire shall be taped directly to plastic water or drain pipe.
3. Tracer wire shall not be fastened directly or indirectly to gas piping.
4. Tracer wire when attached shall be secured to the pipe a minimum of every 10 feet and at all changes of direction.
5. Tape shall be Polyken "930-35", Protecto-Wrap "310", or approved equal.
6. Tracer wire shall be continuous between boxes and shall be tested for continuity.
7. Splices in tracer wire shall be made with a waterproof splice kit to prevent corrosion. Wire nuts shall not be used.

8. The tracer wire shall daylight to grade through a 2" PVC conduit, at the point of the utility entrance to building. PVC conduit shall be capped and labeled as future contact point to locate the utility.

3.2 SCHEDULE

A. Pipes to be marked shall be labeled with text as follows, regardless of which method or material is used:

1. STEAM - 90 PSI: Black lettering; yellow background
2. STEAM - 15 PSI: Black lettering; yellow background
3. STEAM - 5 PSI: Black lettering; yellow background
4. HEATING WATER SUPPLY: White lettering; green background
5. HEATING WATER RETURN: White lettering; green background
6. HIGH PRESSURE CONDENSATE: Black lettering; yellow background
7. PUMPED CONDENSATE: Black lettering; yellow background
8. CHILLED WATER SUPPLY: White lettering; green background
9. CHILLED WATER RETURN: White lettering; green background
10. CONDENSATE DRAIN: White lettering; green background
11. COMPRESSED AIR: White lettering; green background
12. INSTRUMENT AIR - 160-185 PSI: White lettering; black background
13. Underground Piping: Varies
14. Tracer Wire - Natural Gas Pipe Lines: Black lettering; yellow background
15. Tracer Wire - All other buried types: White lettering; green background

B. Steam pipe markers shall include operating steam pressure within pipes shown above.

C. Ductwork and Fan Systems: All fans, filters housings, and access doors shall be labeled with text as follows:

1. WARNING - CHEMICAL FUME EXHAUST: Black lettering; orange/white background
2. WARNING - ISOLATION ROOM EXHAUST: Black lettering; orange/white background

END OF SECTION 23 05 53

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SECTION 23 05 93 - TESTING, ADJUSTING, AND BALANCING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Testing, adjusting, and balancing of air systems.

B. Testing, adjusting, and balancing of heating systems.

C. Testing, adjusting, and balancing of cooling systems.

D. Testing, adjusting, and balancing of plumbing systems.

E. Testing, adjusting, and balancing of energy recovery systems.

F. Measurement of final operating condition of HVAC systems.

1.2 QUALITY ASSURANCE

A. Agency shall be a company specializing in the adjusting and balancing of systems specified in this section with minimum three years' experience. Perform work under supervision of AABC Certified Test and Balance Engineer, NEBB Certified Testing, Balancing and Adjusting Supervisor, SMARTA Certified Air and Hydronic Balancer, or TABB Certified Supervisor.

B. Work shall be performed in accordance with the requirements of the references listed at the start of this section.

1.3 SUBMITTALS

A. Submit copies of report forms, balancing procedures, and the name and qualifications of testing and balancing agency for approval within 30 days after award of Contract.

B. Electronic Copies:

1. Submit a certified copy of test reports to the Architect/Engineer for approval. Electronic copies shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Copies that are not legible will be returned to the Contractor for resubmittal. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.
2. Electronic file size shall be limited to a maximum of 10MB. Larger files shall be divided into files that are clearly labeled as "1 of 2", "2 of 2", etc.
3. All text shall be searchable.
4. Bookmarks shall be used. All bookmark titles shall be an active link to the index page and index tabs.

1.4 REPORT FORMS

A. Submit reports on AABC, SMACNA or NEBB forms. Use custom forms approved by the Architect/Engineer when needed to supply specified information.

B. Include in the final report a schematic drawing showing each system component, including balancing devices, for each system. Each drawing shall be included with the test reports required for that system. The schematic drawings shall identify all testing points and cross-reference these points to the report forms and procedures.

C. Refer to PART 4 for required reports.

1.5 WARRANTY/GUARANTEE

A. The TAB Contractor shall include an extended warranty of 90 days after owner receipt of a completed balancing report, during which time the Owner may request a recheck of terminals, or resetting of any outlet, coil, or device listed in the test report. This warranty shall provide a minimum of 24 manhours of onsite service time. If it is determined that the new test results are not within the design criteria, the balancer shall rebalance the system according to design criteria.

B. Warranty/Guarantee must meet one of the following programs: TABB International Quality Assurance Program, AABC National Project Performance Guarantee, NEBB's Conformance Certification.

1.6 SCHEDULING

A. Coordinate schedule with other trades. Provide a minimum of seven days' notice to all trades and the Architect/Engineer prior to performing each test.

B. Project will be constructed in phases. Provide balancing report after each phase is complete.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.1 GENERAL REQUIREMENTS

A. All procedures must conform to a published standard listed in the References article of this section. All equipment shall be adjusted in accordance with the manufacturer's recommendations. Any system not listed in this specification but installed under the contract documents shall be balanced using a procedure from a published standard listed in the References article.

B. The Balancing Contractor shall incorporate all pertinent documented construction changes (e.g. submittals/shop drawings, change orders, RFIs, ASIs, etc.) and include in the balancing report.

C. Recorded data shall represent actual measured or observed conditions.

D. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing is complete, close probe holes and patch insulation with new materials as specified. Restore vapor barrier and finish as specified.

E. Permanently mark setting of valves, dampers, and other adjustment devices allowing for settings to be restored. Set and lock memory stops.

F. Leave systems in proper working order, replacing belt guards, closing access doors, closing doors to electrical switch boxes, plugging test holes, and restoring thermostats to specified settings.

G. The Balancing Contractor shall measure terminal air box air flow, and the TCC shall adjust DDC readout to match. Refer to Section 23 09 00 for additional information.

H. Installations with systems consisting of multiple components shall be balanced with all system components operating.

3.2 EXAMINATION

A. Before beginning work, verify that systems are complete and operable. Ensure the following:

1. General Equipment Requirements:

a. Equipment is safe to operate and in normal condition.
b. Equipment with moving parts is properly lubricated.
c. Temperature control systems are complete and operable.
d. Proper thermal overload protection is in place for electrical equipment.
e. Direction of rotation of all fans and pumps is correct.
f. Access doors are closed and end caps are in place.

2. Duct System Requirements:

a. All filters are clean and in place. If required, install temporary media.
b. Duct systems are clean and free of debris.
c. Fire/smoke and manual volume dampers are in place, functional and open.
d. Air outlets are installed and connected.
e. Duct system leakage has been minimized.

3. Pipe System Requirements:

a. Coil fins have been cleaned and combed.
b. Hydronic systems have been cleaned, filled, and vented.
c. Strainer screens are clean and in place.
d. Shutoff, throttling and balancing valves are open.

B. Report any defects or deficiencies to Architect/Engineer.

C. Promptly report items that are abnormal or prevent proper balancing.

D. If, for design reasons, system cannot be properly balanced, report as soon as observed.

E. Beginning of work means acceptance of existing conditions.

3.3 PREPARATION

A. Provide instruments required for testing, adjusting, and balancing operations. Make instruments available to the Architect/Engineer for spot checks during testing.

B. Instruments shall be calibrated within six months of testing performed for project, or more recently if recommended by the instrument manufacturer.

3.4 INSTALLATION TOLERANCES

A. ± 10% of scheduled values:

1. Adjust air inlets and outlets to ± 10% of scheduled values.
2. Adjust piping systems to ±10% of design values.

B. ± 5% of scheduled values:

1. Adjust fume exhaust systems to ± 5% of scheduled values.
2. Adjust supply and exhaust air-handling systems for space pressurization to ± 5% of scheduled values, and to provide proper pressurization.

C. + 5% of scheduled values

1. Adjust outdoor air intakes to within + 5% of scheduled values.
2. Adjust exhaust air through energy recovery equipment to within +5% of scheduled values.

D. Adjust supply, return, and exhaust air-handling systems to +10% / -5% of scheduled values.

3.5 ADJUSTING

A. After adjustment, take measurements to verify balance has not been disrupted or that disruption has been rectified.

B. Once balancing of systems is complete, at least one damper or valve must be 100% open.

C. After testing, adjusting and balancing are complete, operate each system and randomly check measurements to verify system is operating as reported in the report. Document any discrepancies.

D. Contractor responsible for each motor shall also be responsible for replacement sheaves. Coordinate with contractor.

E. Contractor responsible for pump shall trim impeller to final duty point as instructed by this contractor on all pumps not driven by a VFD. Coordinate with contractor.

3.6 SUBMISSION OF REPORTS

A. Fill in test results on appropriate forms.

PART 4 - SYSTEMS TO BE TESTED, ADJUSTED AND BALANCED

4.1 VERIFICATION OF EXISTING SYSTEMS.

A. Perform a pre-balance of systems serving the area of construction prior to the start of any other work. Do not make adjustments to the systems. If the systems are not operating at maximum capacity, temporarily drive system to maximum and take readings for the system. Return the system to its original state when measurements are complete. The area that will need to be tested

1. Air Handling Unit:

a. General Requirements:

1) Existing Equipment Tag (if available).
2) Location.
3) Manufacturer, model, arrangement, class, discharge.
4) Fan RPM.

b. Flow Rate:

1) Supply flow rate (cfm)
2) Return flow rate (cfm)
3) Outside flow rate (cfm)
4) Exhaust flow rate (cfm)

c. Pressure Drop and Pressure:

1) Filter pressure drop.
2) Total static pressure. (Indicate if across fan or external to unit).
3) Inlet pressure.
4) Discharge pressure.

2. Exhaust Fan

a. Drawing symbol.
b. Location.
c. Manufacturer and model.
d. Flow rate (cfm).
e. Total static pressure. (Indicate measurement locations).
f. Inlet pressure.
g. Discharge pressure.
h. Fan RPM.

3. Air Terminal (Inlet or Outlet):

a. Room number/location.
b. Terminal type and size.
c. Velocity.
d. Flow rate (cfm)
e. Percent of design flow rate.

4. Air Terminal Unit (Terminal Air Box) Data:

a. General Requirements:

1) Drawing symbol.
2) Location.
3) Manufacturer and model.
4) Size.
5) Type: constant, variable, single, dual duct.

b. Flow Rate:

1) Cooling maximum flow rate (cfm).
2) Heating maximum flow rate (cfm).
3) Minimum flow rate (cfm).
4) Water flow rate (gpm).

c. Temperature:

1) Entering air temperature.
2) Leaving air temperature (in heating mode).
3) Entering water temperature.
4) Leaving water temperature.

d. Pressure Drop and Pressure:

1) Inlet static pressure during testing.
2) Coil air pressure drop.
3) Water pressure drop.

B. Report findings to Architect/Engineer on standard forms. Provide four (4) copies of report.

4.2 GENERAL REQUIREMENTS

A. Title Page:

1. Project name.
2. Project location.
3. Project Architect.
4. Project Engineer (IMEG Corp.).
5. Project General Contractor.
6. TAB Company name, address, phone number.
7. TAB Supervisor's name and certification number.
8. TAB Supervisor's signature and date.
9. Report date.

B. Report Index

C. General Information:

1. Test conditions.
2. Nomenclature used throughout report.
3. Notable system characteristics/discrepancies from design.
4. Test standards followed.
5. Any deficiencies noted.
6. Quality assurance statement.

D. Instrument List:

1. Instrument.
2. Manufacturer, model, and serial number.
3. Range.
4. Calibration date.

4.3 AIR SYSTEMS

A. Duct Leakage Test:

1. Air system and fan.
2. Leakage class.
3. Test pressure.
4. Construction pressure.
5. Flow rate (cfm): specified and actual.
6. Leakage (refer to Section 23 31 00 in the specifications): specified and actual.
7. Statement that fire dampers, reheat coils and other accessories were included in the test.
8. Pass or Fail.
9. Test performed by.
10. Test witnessed by.

B. Air Moving Equipment:

1. General Requirements:

a. Drawing symbol.
b. Location.
c. Manufacturer, model, arrangement, class, discharge.
d. Fan RPM.
e. Multiple RPM fan curve with operating point marked. (Obtain from equipment supplier).
f. Final frequency of motor at maximum flow rate (on fans driven by VFD).

2. Flow Rate:

a. Supply flow rate (cfm): specified and actual.
b. Return flow rate (cfm): specified and actual.
c. Outside flow rate (cfm): specified and actual.
d. Exhaust flow rate (cfm): specified and actual.

3. Pressure Drop and Pressure:

a. Filter pressure drop: specified and actual.
b. Total static pressure: specified and actual. (Indicate if across fan or external to unit).
c. Inlet pressure.
d. Discharge pressure.

C. Fan Data:

1. Drawing symbol.
2. Location.
3. Manufacturer and model.
4. Flow rate (cfm): specified and actual.
5. Total static pressure: specified and actual. (Indicate measurement locations).
6. Inlet pressure.
7. Discharge pressure.
8. Fan RPM.

D. Electric Motors:

1. Drawing symbol of equipment served.
2. Manufacturer, Model, Frame.
3. Nameplate: HP, phase, service factor, RPM, operating amps, efficiency.
4. Measured: Amps in each phase.

E. Duct Traverse:

1. System zone/branch/location.
2. Duct size.
3. Free area.
4. Velocity: specified and actual.
5. Flow rate (cfm): specified and actual.
6. Duct static pressure.
7. Air temperature.
8. Air correction factor.

F. Air Terminal (Inlet or Outlet):

1. Drawing symbol.
2. Room number/location.
3. Terminal type and size.
4. Velocity: specified and actual.

5. Flow rate (cfm): specified and actual.
6. Percent of design flow rate.

G. Air Terminal Unit (Terminal Air Box) Data:

1. General Requirements:

    a. Drawing symbol.
    b. Location.
    c. Manufacturer and model.
    d. Size.
    e. Type: constant, variable, single, dual duct.

2. Flow Rate:

    a. Cooling maximum flow rate (cfm): specified and actual.
    b. Heating maximum flow rate (cfm): specified and actual.
    c. Minimum flow rate (cfm): specified and actual.
    d. Water flow rate (gpm): specified and actual with system performance adjusted as follows:

        1) Adjust heating water system pump to maintain maximum system differential pressure.
        2) Set calibrated balance valve fully open.
        3) Command terminal air box control valve to fully open.
        4) Measure heating coil flow using calibrated balance valve.
        5) Note: Commanding terminal air box control valve to be fully open shall be done on a valve-by-valve basis. Do not command all control valves to be fully open at the same time, as the heating water system may not have sufficient capacity.
        6) Note: After Balancing of all terminal air boxes is complete, release the heating water pump to automatically reset the system DP based on control valve position per sequence of operation requirements.

3. Temperature:

    a. Entering air temperature: specified and actual.
    b. Leaving air temperature (in minimum airflow/heating mode): specified and actual.
    c. Entering water temperature: specified and actual.
    d. Leaving water temperature: specified and actual.

4. Pressure Drop and Pressure:

    a. Inlet static pressure during testing cooling maximum airflow rate (maximum and minimum).
    b. Water pressure drop: specified and actual.

H. Air Flow Measuring Station:

1. Drawing symbol.
2. Service.
3. Location.
4. Manufacturer and model.
5. Size.
6. Flow rate (cfm): specified and actual.
7. Pressure drop: specified and actual.

I. Fume Hood:

1. Drawing symbol.
2. Location.
3. Manufacturer and Model.
4. Total flow rate (cfm): specified and actual.

5. Test velocities.
6. Hood opening dimensions.

J. Positive Air Flow Test:

1. Occupied Supply Air (Max./Min.) Flow rate (cfm): specified and actual.
2. Occupied Return Air (Max./Min.) Flow rate (cfm): specified and actual.
3. Unoccupied Supply Air (Max./Min.) Flow rate (cfm): specified and actual.
4. Unoccupied Return Air (Min./Max.) Flow rate (cfm): specified and actual.

K. Fire, Smoke, and Fire/Smoke Dampers:

1. Damper ID #.
2. System identification.
3. Type.
4. Size.
5. UL assembly number.
6. Location of damper and access door.
7. Fusible link temperature rating.
8. Manufacturer and model.
9. Operation pass/fail/reset.

L. LEED Indoor Chemical and Pollution Exhaust Verification

1. In accordance with LEED EQp2 and EQc5, negative pressurization must be maintained in the following rooms:

    a. Smoking Rooms
    b. Garages
    c. Housekeeping Closets
    d. Laundry Rooms
    e. Copy Rooms
    f. Printing Rooms

2. Verify that each room operates at a negative pressure (compared to each adjacent area and adjacent vertical chase) of at least -0.004 in. w.c. and an average of -0.020 in. w.c. when the doors to the room are closed.
3. Performance of rooms' differential air pressures must be verified by conducting 15 minutes of measurements, with a minimum of 1 measurement every 10 seconds.

    a. This test must be conducted for each adjacent area and adjacent vertical chase with the doors of the room closed.

4.4 HEATING SYSTEMS

A. Pump Data (Primary and Secondary Heating Water Loop Pumps):

1. Existing drawing symbol or equipment TAG
2. Service.
3. Manufacturer, size, and model.
4. Impeller size: specified, actual, and final (if trimmed).
5. Flow Rate (gpm): specified and actual.
6. Pump Head: specified, operating and shutoff.
7. Suction Pressure: Operating and shutoff.
8. Discharge Pressure: Operating and shutoff.
9. Final frequency of motor at maximum flow rate (on pumps driven by VFD).

B. Electric Motors (Associated Heating Water Loop Pump Motors):

1. Drawing symbol of equipment served.
2. Manufacturer, Model, Frame.
3. Nameplate: HP, phase, service factor, RPM, operating amps, efficiency.
4. Measured: Amps in each phase.

C. Heat Exchangers (not all items apply to all units):

1. General Requirements:

a. Drawing symbol.
b. Service.
c. Location.
d. Manufacturer and model.

2. Primary Heat Exchanger:

a. Steam pressure in exchanger: specified and actual.
b. Primary water entering temperature: specified and actual.
c. Primary water leaving temperature: specified and actual.
d. Primary water flow: specified and actual.
e. Primary water pressure drop: specified and actual.

3. Primary water Btuh (gpm x temperature drop x 500). Secondary Heat Exchanger:

a. Secondary water entering temperature: specified and actual.
b. Secondary water leaving temperature: specified and actual.
c. Secondary water flow: specified and actual.
d. Secondary water pressure drop: specified and actual.
e. Secondary water Btuh (gpm x temperature rise x 500).

D. Heating Coils:

1. General Requirements:

a. Drawing symbol.
b. Service.
c. Location.
d. Manufacturer and model.
e. Size.

2. Flow Rate:

a. Flow rate (cfm): specified and actual.
b. Water flow rate: specified and actual.

3. Temperature:

a. Entering air temperature: specified and actual.0
b. Leaving air temperature: specified and actual.
c. Entering water temperature: specified and actual.
d. Leaving water temperature: specified and actual.

4. Pressure Drop and Pressure:

a. Air pressure drop: specified and actual.
b. Steam pressure after valve: specified and actual.
c. Water pressure drop: specified and actual.

5. Energy:

   a. Air Btuh (cfm x temp rise x 1.09).
   b. Water Btuh (gpm x temp drop x 500). Repeat tests if not within 10% of air Btuh.

E. Terminal Heat Transfer Units:

1. General Requirement:

   a. Drawing symbol.
   b. Location.
   c. Manufacturer and model.
   d. Include air data only for forced air units.

2. Flow Rate:

   a. Flow rate (cfm): specified and actual.
   b. Water flow rate (cfm): specified and actual.

3. Temperature:

   a. Entering air temperature: specified and actual.
   b. Leaving air temperature: specified and actual.
   c. Entering water temperature: specified and actual.
   d. Leaving water temperature: specified and actual.

4. Energy:

   a. Air Btuh (cfm x temperature rise x 1.09).
   b. Water Btuh (gpm x temperature drop x 500). Repeat tests if not within 10% of air Btuh.

4.5 COOLING SYSTEMS

A. Pump Data:

1. General Requirements:

   a. Drawing symbol.
   b. Service.
   c. Manufacturer, size, and model.
   d. Impeller size: specified, actual, and final (if trimmed).
   e. Final frequency of motor at maximum flow rate. (On pumps driven by VFD.)

2. Flow Rate:

   a. Flow Rate (gpm): specified and actual.

3. Pressure Drop and Pressure:

   a. Pump Head: specified, operating and shutoff.
   b. Suction Pressure: Operating and shutoff.
   c. Discharge Pressure: Operating and shutoff.

B. Electric Motors:

1. Drawing symbol of equipment served.
2. Manufacturer, Model, Frame.
3. Nameplate: HP, phase, service factor, RPM, operating amps, efficiency.
4. Measured: Amps for each phase.

C. Cooling Coils:

1. General Requirements:

a. Drawing symbol.
b. Service.
c. Location.
d. Size.
e. Manufacturer and model.

2. Temperature:

a. Entering air DB temperature: specified and actual.
b. Entering air WB temperature: specified and actual.
c. Leaving air DB temperature: specified and actual.
d. Leaving air WB temperature: specified and actual.
e. Entering water temperature: specified and actual.
f. Leaving water temperature: specified and actual.

3. Flow Rate:

a. Flow rate (cfm): specified and actual.
b. Water flow rate (gpm): specified and actual.

4. Pressure Drop and Pressure:

a. Water pressure drop: specified and actual.
b. Air pressure drop: specified and actual.

5. Energy:

a. Air Btuh (cfm x enthalpy change x 4.5).
b. Water Btuh (gpm x temperature drop x 500). Repeat tests if not within 10% of air Btuh.

D. Terminal Heat Transfer Units:

1. General Requirements:

a. Drawing symbol.
b. Location.
c. Manufacturer and model.
d. Include air data only for forced air units.

2. Temperature:

a. Entering air DB temperature: specified and actual.
b. Leaving air DB temperature: specified and actual.
c. Entering water temperature: specified and actual.
d. Leaving water temperature: specified and actual.

3. Flow rate:

a. Flow rate (cfm): specified and actual.
b. Water flow (gpm): specified and actual.

4. Energy:

a. Air Btuh (cfm x temperature rise x 1.09).
b. Water Btuh (gpm x temperature drop x 500). Repeat tests if not within 10% of air Btuh.

4.6 PLUMBING SYSTEMS

A. Pump Data:

1. Drawing symbol.
2. Service.
3. Manufacturer, size, and model.
4. Impeller size: specified, actual, and final (if trimmed).
5. Flow Rate (gpm): specified and actual.
6. Pump Head: specified, operating and shutoff.
7. Suction Pressure: operating and shutoff.
8. Discharge Pressure: operating and shutoff.

B. Electric Motors:

1. Drawing symbol of equipment served.
2. Manufacturer, model, frame.
3. Nameplate: HP, phase, service factor, RPM, operating amps, efficiency.
4. Measured: Amps for each phase.

C. Balancing Valve:

1. Drawing symbol.
2. Service.
3. Location.
4. Size.
5. Manufacturer and model.
6. Flow rate (gpm): specified and actual.
7. Pressure drop: specified and actual.

D. Heat Exchangers (not all items apply to all units):

1. General Requirements:

   a. Drawing symbol.
   b. Service.
   c. Location.
   d. Manufacturer and model.

2. Primary Heat Exchanger:

   a. Steam pressure in exchanger: specified and actual.
   b. Primary water entering temperature: specified and actual.
   c. Primary water leaving temperature: specified and actual.
   d. Primary water flow: specified and actual.
   e. Primary water pressure drop: specified and actual.
   f. Primary water Btuh (gpm x temperature drop x 500).

3. Secondary Heat Exchanger:

   a. Secondary water entering temperature: specified and actual.
   b. Secondary water leaving temperature: specified and actual.
   c. Secondary water flow: specified and actual.
   d. Secondary water pressure drop: specified and actual.
   e. Secondary water Btuh (gpm x temperature rise x 500).

4.7 ENERGY RECOVERY SYSTEMS

A. Air Systems - Air energy recovery devices shall be tested at ambient temperatures of less than 40°F or greater than 85°F.

1. Run-around Coils:

a. General Requirements:

1) Drawing Symbol.
2) Location.
3) Water Flow Rate (gpm).

b. Primary Coil:

1) Primary Coil Air Pressure Drop.
2) Primary Coil Entering Air Temperature.
3) Primary Coil Leaving Air Temperature.
4) Primary Coil Water Pressure Drop.
5) Primary Coil Entering Water Temperature.
6) Primary Coil Leaving Water Temperature.

c. Secondary Coil:

1) Secondary Coil Air Pressure Drop.
2) Secondary Coil Entering Air Temperature.
3) Secondary Coil Leaving Air Temperature.
4) Secondary Coil Water Pressure Drop.
5) Secondary Coil Entering Water Temperature.
6) Secondary Coil Leaving Water Temperature.

B. Water Systems:

1. Heat Exchanger

a. General Requirements:

1) Drawing Symbol.
2) Location.

b. Primary Water:

1) Primary Entering Water Temperature.
2) Primary Leaving Water Temperature.
3) Primary Water Pressure Drop.
4) Primary Water Flow Rate (gpm).

c. Secondary Water:

1) Secondary Entering Water Temperature.
2) Secondary Leaving Water Temperature.
3) Secondary Water Pressure Drop.
4) Secondary Water Flow Rate (gpm).

END OF SECTION 23 05 93

SECTION 23 07 13 - DUCTWORK INSULATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Ductwork Insulation.

B. Insulation Jackets.

1.2 QUALITY ASSURANCE

A. Applicator: Company specializing in ductwork insulation application with five years minimum experience. When requested, installer shall submit manufacturer's certificate indicating qualifications.

B. Materials:

1. Listed and labeled for flame spread/smoke developed rating of no more than 25/50 when tested per ASTM E84 or UL 723 as required by code.
2. Fungal Resistance: No growth when tested in accordance with ASTM G21 (antifungal test).
3. Rated velocity on coated air side for air erosion in accordance with UL 181 at 5,000 fpm minimum.
4. UL listed in Category HNKT.

C. Adhesives: UL listed, meeting NFPA 90A/90B requirements.

1.3 SUBMITTALS

A. Submit shop drawings per Section 23 05 00. Include product description, list of materials and thickness for each service, and location.

B. Submit manufacturer's installation instructions.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Type A: Flexible Fiberglass - Outside Wrap; ANSI/ASTM C553; commercial grade; 0.28 / 0.26 (Out-Of-Package/Installed-Compressed 25%) maximum 'K' value at 75°F; foil scrim Kraft facing, 1.0 lb./cu. ft. density. Submit both "Out of Package" and "Installed-Compressed 25%" K and R-values.

B. Type B: Semi-rigid Fiberglass Board Wrap - Outside Application; ANSI/ASTM C612, Class 1; 0.25 maximum 'K' value at 75°F; foil scrim Kraft facing, 3 lb./cu. ft. density.

C. Type C: Flexible Fiberglass Liner; ANSI/ASTM C1071; 0.28 maximum 'K' value at 75°F; 1.5 lb/cu ft minimum density; coated air side for 5000 fpm air velocity.

D. Type E: Double wall ductwork insulation; fiberglass; 0.27 maximum 'K' value at 75°F mean temperature; 1.5 lb/cu ft density.

R-VALUE PER THICKNESS

	THICKNESS	0.5	1	1.5	2	2.5	3	4	5
TYPE	K-FACTOR	R-VALUE							
Flexible Fiberglass Outside Wrap	0.28			5.4	7.1	8.9	10.7	14.3	17.9
Semi-Rigid Fiberglass Board Wrap	0.25			6.0	8.0	10.0	12.0	16.0	20.0
Flexible Fiberglass Liner	0.28	1.8	3.6	5.4	7.1	8.9	10.7	14.3	17.9
Rigid fiberglass liner	0.23		4.3	6.5	8.7	10.9	13.0	17.4	21.7
Double Wall Ductwork	0.27		3.7	5.6	7.4	9.3	11.1	14.8	18.5
Flexible High Temp Rigid Preformed Fiberglass Acoustical Liner	0.23		4.3	6.5	8.7	10.9	13.0	17.4	21.7

2.2 JACKETS

A. Vapor Barrier Jackets: Kraft reinforced foil scrim vapor barrier with self-sealing adhesive joints. Beach puncture resistance ratio of at least 25 units. Tensile strength: 35 psi minimum. Single, self-seal acrylic adhesive on longitudinal jacket laps and butt strips.

2.3 JACKET COVERINGS

A. Aluminum Jackets: ASTM B209; 0.016" thick; smooth or embossed stucco finish with Z edge seams and aluminum bands for outdoor use. Where colored jacket covers are called for, provide factory-applied hard film acrylic paint in color selected by Architect.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install materials in accordance with manufacturer's instructions, codes, and industry standards.

B. Install materials after ductwork has been tested.

C. Clean surfaces for adhesives.

D. Provide insulation with vapor barrier when air conveyed may be below ambient temperature.

E. Exterior Duct Wrap - Flexible, Type A:

1. Apply with edges tightly butted.
2. Cut slightly longer than perimeter of duct to insure full thickness at corners. Do not wrap excessively tight.
3. Seal joints with adhesive backed tape.
4. Apply so insulation conforms uniformly and firmly to duct.
5. Seal all penetrations of the vapor barrier by strap hangers or slip cable hangers with adhesive backed tape.
6. Provide high-density insulation inserts on rectangular ducts at trapeze duct hangers to prevent crushing of insulation. Provide high-density insulation inserts with clamp-on round ducts requiring two (2) rods or straps to prevent crushing of insulation. Maintain continuous vapor barrier through the hanger.

7. Tape all joints with Royal Tapes #RT 350 (216-439-7229), Venture Tape 1525CW, or Compac Type FSK. No substitutions will be accepted without written permission from the Architect/Engineer.
8. Press tape tightly to the duct covering with a squeegee for a tight continuous seal. Fish mouths and loose tape edges are not acceptable.
9. Staples may be used, but must be covered with tape.
10. Vapor barrier must be continuous.
11. Mechanically fasten on 12" centers at bottom of ducts over 24" wide and on all sides of vertical ducts.

F. Semi Rigid Fiberglass Board Wrap - Type B (Indoor Use):

1. Impale on pins welded to the duct and secured with speed clips. Clip pins off close to speed clips.
2. Space pins as needed to hold insulation firmly against duct, but not less than one pin per square foot. Pins must be long enough to avoid compressing the insulation.
3. Seal all joints and speed clips with glass fabric set in adhesive or a 3" wide strip of Royal Tapes #RT 350 (216-439-7229), Venture Tape 1525CW, or Compac Type FSK facing tape.
4. For small areas, secure insulation with adhesive over the entire surface of the duct. Use adhesive in addition to pins as needed to prevent sagging on horizontal surfaces.

G. Semi Rigid Fiberglass Board Wrap - Type B (Outdoor Use):

1. Impale on pins welded to the duct and secured with speed clips. Clip pins off close to speed clips.
2. Space pins as required to hold insulation firmly against duct, but not less than one pin per square foot. Pins must be long enough to avoid compressing the insulation.
3. Seal all joints and speed clips with glass fabric set in adhesive or a 3" wide strip of the same facing tape with adhesive.
4. For small areas, secure insulation with adhesive over the entire surface of the duct. Use adhesive in addition to pins as needed to prevent sagging on horizontal surfaces.
5. Install vapor barrier jacket. Cover with aluminum jacket covering with seams on the bottom of horizontal ductwork.
6. Seal all butt joints with metal draw bands screwed to jacket and filled with sealant. Seal all joints watertight.
7. Provide positive slope on top of all horizontal surfaces to prevent ponding of water.

H. Interior Insulation - Flexible Duct Liner, Type C:

1. Observation of Duct Lining:

   a. After installation of ductwork, Architect/Engineer may select random observation points in each system.

      1) At each observation point, cut and remove an 18" x 18" section of ductwork and liner for verification of installation.
      2) Random observation points based on one opening per 75 lineal ft. of total duct run.

   b. When any of the observation points shows non-compliance, additional points will be designated by the Architect/Engineer, and observation repeated.
   c. If 20% of points observed do not comply, remove and replace all lined ducts and repeat tests. Where replacement is not required, correct all non-compliances.
   d. At end of observation, repair all duct lining and observation holes by installing standard, insulated, hinged access doors per Section 23 33 00.
   e. Paint or finish to match adjacent duct surfaces.

2. Impale on spindle anchors welded or mechanically fastened to the duct. Adhesive or glue fastened anchors are not acceptable. Maximum anchor spacing per SMACNA Duct Construction Standards or manufacturer's recommendations, whichever is more restrictive. Locate pins less than 3" from corners and at intervals not over 6" around the perimeter at leading and trailing edges. Locate pins within 3" of transverse joints and at intervals not over 16" long the length of the duct. Pins must be long enough to prevent compressing the insulation.
3. In addition to anchors, secure liner with UL listed adhesive covering over 90% of the duct surface.
4. Install per the latest edition of the SMACNA Manual.

5. Leading edges shall be covered as follows:

   a. For duct velocities below 3000 fpm, coat leading edges with adhesive. Neatly butt liner without gaps at transverse joints. Cut liner flush with end of the duct section for tight joints with no exposed duct. If adhesive is shop installed, field apply additional adhesive to the end of each duct section for complete adhesion of the liner. Protect edges from dirt and debris.
   b. For duct velocities above 3000 fpm, cover leading edges with metal nosing. Use nosing on upstream edges of each section of duct. If the duct can be installed in either direction, provide nosing on each end or clearly mark the duct to allow visual verification after installation. Verify duct velocities based on the scheduled air flow rates and determine where metal nosing is required.
   c. Install metal nosing in the following locations (regardless of velocity):

      1) The first three fittings downstream of all fans.
      2) At all duct liner interruptions. This includes fire dampers, access doors, branch connections, and all other locations where the edge of the liner is exposed.
      3) Trailing edges of transverse joints do not require metal nosings.

6. Overlap liner at longitudinal joints. Make longitudinal joints at corners of the duct unless the duct size does not allow this. Coat longitudinal joints with adhesive at velocities over 2500 fpm.
7. Seal all damaged duct liner with adhesive and glass cloth. Do not damage duct liner surface coatings.
8. Duct dimensions given are net inside dimensions. Increase sheet metal to allow for insulation thickness.

I. Double-Wall Ductwork Insulation - Type E:

   1. Install insulation per manufacturer's recommendations.
   2. Duct dimensions given are net inside dimensions of inner wall.

J. Continue insulation with vapor barrier through penetrations unless code prohibits.

K. Provide 2" wide, 24" high, 26 gauge, galvanized sheet metal corner protection angles for all externally insulated ductwork extending to a floor or curb.

3.2 SCHEDULE

A. Refer to Section 23 31 00 for scheduling of insulation.

END OF SECTION 23 07 13

SECTION 23 07 19 - HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Piping Insulation.

B. Insulation Jackets.

1.2 QUALITY ASSURANCE

A. Applicator: Company specializing in piping insulation application with five years minimum experience.

B. Materials: Listed and labeled for flame spread/smoke developed rating of no more than 25/50 when tested per ASTM E84 or UL 723 as required by code. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers with appropriate markings of applicable testing agency.

C. Products shall not contain asbestos, lead, mercury, or mercury compounds.

D. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.

E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

1.3 SUBMITTALS

A. Submit shop drawings per Section 23 05 00. Include product description, list of materials and thickness for each service, and locations.

PART 2 - PRODUCTS

2.1 INSULATION

A. Type A: Glass fiber; ANSI/ASTM C547; 0.24 maximum 'K' value at 75°F; non-combustible. All-purpose polymer or polypropylene service jacket, listed and labeled at no more than 25/50 when tested per ASTM E84 or UL 723 as required by code.

B. Type B: Flexible elastomeric foam insulation; closed-cell, sponge or expanded rubber (polyethylene type is not permitted); ANSI/ASTM C534, Grade 1 Type I for tubular materials; flexible plastic; 0.25 maximum 'K' value at 75°F, listed and labeled at more than 25/50 when tested per ASTM E84 or UL 723 as required by code. Maximum 1" thick per layer where multiple layers are specified.

2.2 VAPOR BARRIER JACKETS

A. All-purpose polymer or polypropylene service jacket vapor barrier with self-sealing adhesive joints. Beach puncture resistance ratio of at least 50 units. Tensile strength: 35 psi minimum. Single, self-seal acrylic adhesive on longitudinal jacket laps and butt strips.

2.3 JACKET COVERINGS

A. Aluminum Jackets: ASTM C1729; 0.016" thick (thicker where required by ASTM C1729); stucco embossed finish with Z edge seams and aluminum bands for outdoor use. Where colored jacket covers are called for, provide factory-applied hard film acrylic paint in color selected by Architect.

B. Stainless Steel Jackets: ASTM C1767. Type 304 stainless steel; 0.010" thick (thicker where required by ASTM C1729); smooth finish with Z edge seams and stainless steel bands for outdoor use.

C. Plastic Jackets and Fitting Covers: High impact, glossy white, 0.020" thick, self-extinguishing plastic. Suitable for use indoors or outdoors with ultraviolet inhibitors. Suitable for -40°F to 150°F. Listed and labeled at no more than 25/50 when tested per ASTM E84 or UL 723 as required by code.

2.4 REMOVABLE INSULATION JACKETS

A. Removable insulation jackets shall consist of outer covering, interstitial insulation material, and inner covering.

B. Inner and outer covering shall be constructed from a minimum 16.5 oz./yd2 PTFE fiberglass composite and suitable for insulating surface temperatures up to 550°F.

C. Interstitial insulation blanket shall be minimum 1-1/2" thick and shall consist of either:

1. Silica and glass-fiber insulation felts and blankets - minimum 6 lb./ft3 density.
2. E-type glass-fiber felts and blankets - minimum 6 lb./ft3 density.

D. Construction: Inner and outer covering with interstitial insulation material shall be joined into a single assembly using a double sewn lock stitch with 4-6 stitches/inch. The thread used shall be able to withstand minimum 550°F surface temperatures without degradation. The use of hog rings, staples, and wires for closure of assembly are not acceptable. The interstitial insulation shall be sewn as an integral part of the inner and outer coverings to prevent shifting of the insulation. Insulation pins are not an allowable method of preventing the insulation from shifting and shall not be used.

E. No raw cut jacket edges shall be exposed.

F. Jackets shall be fastened to equipment and piping components using hook and loop (Velcro) straps and minimum 1" slide buckles.

G. Jacket coverings shall have an inner covering edge with a continuous strip of hook & loop closure (Velcro) that is parallel to the seam and overlaps the outer covering by a minimum of 2 inches.

H. Manufacturers:

1. Firwin Corp
2. Lewco Specialty Products
3. ThermaXX Jackets LLC
4. Approved equivalent

PART 3 - EXECUTION

3.1 PREPARATION

A. Install insulation after piping has been tested. Pipe shall be clean, dry and free of rust before applying insulation.

B. Patch and repair torn insulation. Paint to match adjacent insulation surface.

3.2 INSTALLATION

A. General Installation Requirements:

1. Install materials per manufacturer's instructions, building codes and industry standards.
2. Continue insulation with vapor barrier through penetrations. This applies to all insulated piping. Maintain fire rating of all penetrations.
3. All piping and insulation that does not meet 25/50 that is in an air plenum shall have written approval from the Authority Having Jurisdiction and the local fire department for authorization and materials approval. If approval has been allowed, the non-rated material shall be wrapped with a product that has been listed and labeled having a flame spread index of not more than 25 and a smoke-developed index of not more than 50 when tested as a composite in accordance with ASTM E84 or UL 723.
4. On 1" and smaller piping routed through metal wall studs, provide a plastic grommet to protect the piping. The piping shall be insulated between the wall studs, and the insulation shall butt up to each stud.

B. Insulated Piping Operating Below 60°F:

1. Insulate fittings, valves, unions, flanges, flexible connections, flexible hoses, and expansion joints. Seal all penetrations of vapor barrier.
2. On piping operating below 60°F in locations that are not mechanically cooled (e.g., penthouses, mechanical rooms, tunnels, chases at exterior walls, etc.), Type B insulation shall be used.
3. All balance valves and strainers with fluid operating below 60°F shall be insulated with a removable plug wrapped with vapor barrier tape to allow access for reading and adjusting of the balancing valve and cleaning and servicing of the balancing valve.

C. Insulated Piping Operating Between 60°F and 140°F:

1. Do not insulate flanges and unions, but bevel and seal ends of insulation at such locations. Insulate all fittings, valves and strainers.

D. Insulated Piping Operating Above 140°F:

1. Insulate fittings, valves, flanges, float & thermostatic steam traps, and strainers. On gate valves, the insulation shall be extended to cover the entire valve bonnet, leaving only the portion of the stem that is above the bonnet and valve operator exposed.
2. All balance valves with fluid operating above 140°F shall be insulated and an opening shall be left in the insulation to allow for reading and adjusting the valve.
3. The use of removable insulation jackets is acceptable for insulating large and non-cylindrical shaped piping components (e.g., check valves, pressure regulating valves, calibrated balance valves, gate valve bonnets, F&T traps, strainers, line sets, and the like).

E. Refrigerant Piping:

1. On refrigerant piping (25°F and above) and not required to meet the 25/50 flame/smoke, provide at each strut or clevis support an insulation coupling to support pipe and to accept insulation thickness of adjoining insulation, to prevent insulation from sagging and crushing. The coupling shall be suitable for planned temperatures, use with specified pipe material, and shall be a 360°, one-piece cylindrical segment. Use mechanical fasteners where coupling cannot be installed on pipe during installation. Contractor shall apply adhesive to ends of insulation entering insulation coupling to maintain vapor barrier.

F. Exposed Piping:

1. Locate and cover seams in least visible locations.
2. Where exposed insulated piping extends above the floor, provide a sheet metal guard around the insulation extending 12" above the floor. Guard shall be 0.016" cylindrical smooth or stucco aluminum and shall fit tightly to the insulation.

3.3 SUPPORT PROTECTION

A. Provide a shield on all insulated piping at each support between the insulation jacket and the support.

B. On all insulated piping greater than 1-1/2", provide shield with insulation insert of same thickness and contour as adjoining insulation at each support, between the pipe and insulation jacket, to prevent insulation from sagging and crushing. Inserts shall be as follows:

1. The insert shall be suitable for planned temperatures, be suitable for use with specific pipe material, and shall be a minimum 180° cylindrical segment the same length as metal shields. Inserts shall be:

a. Molded hydrous calcium silicate (only use for pipes with operating temperatures above 90°F, with a minimum compressive strength of 100 psi is acceptable for pipe sizes 14" and below. For pipe sizes larger than 14", provide rolled steel plate in addition to the shield.
b. Polyisocyanurate insulation (for pipes below 300°F with a minimum compressive strength of 24 psi is acceptable for pipe sizes 3" and below, minimum 60 psi for pipe sizes 4" to 10". For pipe sizes larger than 10", provide rolled steel plate in addition to the shield. Where insulation is installed on piping located within return air plenums and mechanical rooms, insulation shall be listed and labeled at no more than 25/50 when tested per ASTM E84 or UL 723 as required by code.
c. Cellular glass (for all temperature ranges) with a minimum compressive strength of 90 psi is acceptable for pipe sizes 14" and below. For pipe sizes larger than 14, provide rolled steel plate in addition to the shield.
d. Phenolic (for pipes operating below 250°F with a minimum compressive strength of 90 psi is acceptable for pipe sizes 14" and below. For pipe sizes larger than 14", provide rolled steel plate in addition to the shield.
e. As an alternative to separate pipe insulation insert and saddle, properly sized manufactured integral rigid insulation insert and shield assemblies may be used.

1) Products:

a) Buckaroo CoolDry
b) Cooper/B-Line Fig. B3380 through B3384
c) Pipe Shields A1000, A2000

f. Insulation Couplings:

1) Molded thermoplastic slip coupling, -65°F to 275°F, sizes up to 4-1/8" OD, and receive insulation thickness up to 1". Suitable for use indoors or outdoors with UV stabilizers. Vertical insulation riser clamps shall have a 1,000lb vertical load rating. On cold pipes operating below 60°F, cover joint and coupling with vapor barrier mastic to ensure continuous vapor barrier.
2) Horizontal Strut Mounted Insulated Pipe Manufacturers:

a) Klo-Shure or equal

3) Vertical Manufacturers:

a) Manufacturers: Klo-Shure Titan or equal

g. Rectangular blocks, plugs, or wood material are not acceptable.
h. Temporary wood blocking may be used by the Piping Contractor for proper height; however, these must be removed and replaced with proper inserts by the Insulation Contractor. Refer to Supports and Anchors specification section for additional information.

C. Neatly finish insulation at supports, protrusions, and interruptions.

D. Install metal shields between all hangers or supports and the pipe insulation. Shields shall be galvanized sheet metal, half-round with flared edges. Adhere shields to insulation. On cold piping, seal the shields vapor-tight to the insulation as required to maintain the vapor barrier, or add separate vapor barrier jacket.

E. Shields shall be at least the following lengths and gauges:

Pipe Size	Shield Size
1/2" to 3-1/2"	12" long x 18 gauge
4"	12" long x 16 gauge
5” to 6"	18" long x 16 gauge
8” to 14"	24" long x 14 gauge
16” to 24"	24" long x 12 gauge

F. Ferrous hot piping 4 inches and larger, provide steel saddle at rollers as described in Section 23 05 29 "HVAC Supports and Anchors".

G. Minimum 1/4" rolled galvanized steel plates shall be provided in addition to the sleeves as reinforcement on large pipes to reduce point loading on roller, trapeze hanger and strut support locations depending on insulation compressive strength. Refer to section above for exact locations.

3.4 INSULATION

A. Type A Insulation:

1. All Service Jackets: Seal all longitudinal joints with self-seal laps using a single pressure sensitive adhesive system. Do not staple.
2. Insulation without self-seal lap may be used if installed with Benjamin Foster 85-20 or equivalent Chicago Mastic, 3M or Childers lap adhesive.
3. Apply insulation with laps on top of pipe.
4. Fittings, Valve Bodies and Flanges: For 4" and smaller pipes, insulate with 1 lb. density insulation wrapped under compression to a thickness equal to the adjacent pipe insulation. For pipes over 4", use mitered segments of pipe insulation. Finish with preformed plastic fitting covers. Secure fitting covers with pressure sensitive tape at each end. Overlap tape at least 2" on itself. For pipes operating below 60°F, seal fitting covers with vapor retarder mastic in addition to tape.

B. Type B Insulation:

1. Install per manufacturer’s instructions or ASTM C1710.
2. Elastomeric Cellular Foam: Where possible, slip insulation over the open end of pipe without slitting. Seal all butt ends, longitudinal seams, and fittings with adhesive. At elbows and tees, use mitered connections. Do not compress or crush insulation at cemented joints. Joints shall be sealed completely and not pucker or wrinkle. Paint the outside of outdoor insulation with two coats of latex enamel paint recommended by the manufacturer.
3. Insulation Installation on Straight Pipes and Tubes:

   a. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
   b. Insulation must be installed in compression to allow for expansion and contraction. Insulation shall be pushed onto the pipe, never pulled. Stretching of insulation may result in open seams and joints.

4. Insulation Installation on Valves and Pipe Specialties:

   a. Install preformed sections of same material as straight segments of pipe insulation when available.
   b. When preformed sections are not available, install mitered sections of pipe insulation to valve body.

c. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation.

3.5 JACKET COVER INSTALLATION

A. Metal Covering:

1. Provide vapor barrier as specified for insulation type. Cover with aluminum stainless jacket covering with seams located on the bottom of horizontal piping. Include fittings, joints and valves.
2. Seal all interior and exterior butt joints with metal draw bands and sealant. Seal all exterior joints watertight.
3. Interior joints do not need to be sealed.
4. Use metal covering on the following pipes:

   a. All exterior piping.
   b. Engine exhaust piping (interior).
   c. All exposed piping in finished spaces.
   d. All exposed piping in areas noted on drawings.
   e. All Type D, H, I and J insulation.

5. Use colored aluminum jacket covers on the following pipes:

   a. All exterior piping.

B. Plastic Covering:

1. Provide vapor barrier as specified for insulation type. Cover with plastic jacket covering. Position seams to shed water.
2. Solvent weld all joints with manufacturer recommended cement.
3. Overlap all laps and butt joints 1-1/2" minimum. Repair any loose ends that do not seal securely. Solvent weld all fitting covers in the same manner. Final installation shall be watertight.
4. All joints in areas noted shall meet USDA standards for Totally Sealed Systems, including overlaps of 1" on circumferential and 1.5" to 2" on longitudinal seams.
5. Use plastic insulation covering on all exposed pipes including, but not limited to:

   a. All exposed piping in finished spaces.
   b. All exposed piping in areas noted on drawings.
   c. All exposed piping in locker rooms.
   d. All exposed piping below 8'-0" above floor.
   e. All piping in mechanical rooms and/or tunnels that is subject to damage from normal operations. (Example: Piping that must be stepped over routinely.)

6. Elastomeric piping insulation may have two coats of latex paint instead of plastic jacket.

3.6 SCHEDULE

A. Refer to drawings for insulation schedule.

END OF SECTION 23 07 19

SECTION 23 08 01 - COMMISSIONING OF HVAC

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Description

B. Responsibilities

C. Related Work

D. Test Equipment

1.2 DESCRIPTION

A. The purpose of this section is to specify Division 23 responsibilities in the commissioning process.

B. The systems to be commissioned are the building mechanical systems in IECC 2012 Section C408 applicable to the project.

1. AHU
2. Exhaust Fans
3. Air Terminal Box
4. Air Valves
5. Pumps
6. Heat Exchangers

1.3 RESPONSIBILITIES

A. Commissioning requires the participation of the Division 23 Contractor to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Section 01 91 01. Division 23 Contractor shall be familiar with all parts of Section 01 91 01 and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

B. Refer to Section 01 91 01 for more information.

1.4 RELATED WORK

A. Specific commissioning requirements are given in the following sections of these specifications. All the following sections apply to the Work of this section.

1. Section 01 78 23 - Operations and Maintenance
2. Section 01 79 00 - Demonstration and Training
3. Section 01 91 01 - Commissioning
4. Section 22 08 01 - Commissioning of Plumbing
5. Section 26 08 01 - Commissioning of Electrical

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. The Contractor shall provide all test equipment necessary to fulfill the testing requirements of this Division. This equipment includes, but is not limited to, the following:

1. Handheld temperature and relative humidity meter.
2. Infrared thermometer gun.
3. Analog differential pressure gauge and associated tubing.
4. Portable computer with access to the building automation system.

B. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the related specifications. If not otherwise noted, the following minimum requirements apply:

1. Temperature sensors and digital thermometers shall have a certified calibration within the past year to an accuracy of 0.5°F and a resolution of +/- 0.1°F.
2. Pressure sensors shall have an accuracy of +/- 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year.
3. All equipment shall be calibrated according to the manufacturer's recommended intervals and when dropped or damaged. Calibration tags shall be affixed or certificates readily available.

C. Refer to Section 01 91 01 for additional Division 23 requirements.

PART 3 - EXECUTION

A. Refer to Section 01 91 01 for more information.

END OF SECTION 23 08 01

SECTION 23 09 00 - CONTROLS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Complete System of Automatic Controls.

B. Control Devices, Components, Wiring and Material.

C. Instructions for Owners.

D. Critical Environment Controls (refer to Section 23 09 20).

1.2 QUALITY ASSURANCE

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

B. TCC: Company specializing in the work of this section with minimum five years temperature control experience.

C. Technician: Minimum five years' experience installing commercial temperature control systems.

D. TCCs are limited to firms regularly employing a minimum of five full-time temperature control technicians within 100 miles of the job site.

1.3 REFERENCES

A. AMCA 500 - Test Methods for Louvers, Dampers and Shutters.

B. ANSI/ASHRAE/IES Standard 90.1 (latest published edition) - Energy Standard for Buildings Except Low-Rise Residential Buildings.

C. ANSI/ASHRAE Standard 135-2001: BACnet® - A Data Communication Protocol for Building Automation and Control Networks, including all amendments.

D. ANSI/NEMA 250 - Enclosures for Electrical Equipment (1000 volts Maximum).

E. ANSI/NFPA 70 - National Electrical Code.

F. ANSI/NFPA 90A - Installation of Air-Conditioning and Ventilation Systems.

G. ASHRAE 62.1 - Ventilation for Acceptable Indoor Air Quality.

H. ASHRAE 85 - Automatic Control Terminology for Heating, Ventilating, Air Conditioning.

I. ANSI/ASME B16.22 - Wrought Copper and Copper Alloy Solder Joint Pressure Fittings.

J. ANSI/ASTM B32 - Solder Metal.

K. ASTM B280 - Seamless Copper Tube for Air Conditioning & Refrigeration Field Service.

L. ASTM D1693 - Environmental Stress - Cracking of Ethylene Plastics.

1.4 SUBMITTALS

A. Equipment Coordination:

1. The Controls Contractor shall obtain approved equipment submittals from other contractors to determine equipment wiring connections, to choose appropriate controllers, and to provide programming.
2. Control valve selections shall be based on flow rates shown in approved shop drawings.
3. Coordinate the control interface of all equipment with the equipment manufacturers prior to submittal submission.

B. Shop Drawings:

1. Submit shop drawings per Section 23 05 00. In addition, submit an electronic copy of the shop drawings in Adobe Acrobat (.pdf) format to the Owner for review.
2. Cross-reference all control components and point names in a single table located at the beginning of the submittal with the identical nomenclature used in this section.
3. Submittal shall also include a trunk cable schematic diagram depicting operator workstations, control panel locations and a description of the communication type, media and protocol.
4. System Architecture: Provide riser diagrams of wiring between central control unit and all control panels. This shall include specific protocols associated with each level within the architecture. Identify all interface equipment between CPU and control panels. The architecture shall include interface requirements with other systems including, but not limited to, security systems, lighting control, fire alarm, elevator status, and power monitoring system.
5. Diagrams shall include:

   a. Wiring diagrams and layouts for each control panel showing all termination numbers.
   b. Schematic diagrams for all control, communication, and power wiring. Provide a schematic drawing of the central system installation. Label all cables and ports with computer manufacturers' model numbers and functions. Show all interface wiring to the control system.
   c. Identification of all control components connected to emergency power.
   d. Schematic diagrams for all field sensors and controllers.
   e. A schematic diagram of each controlled system. The schematics shall have all control points labeled. The schematics shall graphically show the location of all control elements in the system.
   f. A schematic wiring diagram for each controlled system. Each schematic shall have all elements labeled. Where a control element is the same as that shown on the control system schematic, label it with the same name. Label all terminals.
   g. A tabular instrumentation list for each controlled system. The table shall show element name, type of device, manufacturer, model number and product data sheet number.
   h. All installation details and any other details required to demonstrate that the system will function properly.
   i. All interface requirements with other systems.

6. The network infrastructure shall conform to the published guidelines for wire type, length, number of nodes per channel, termination, and other relevant wiring and infrastructure criteria as published. The number of nodes per channel shall be no more than 80% of the defined segment (logical or physical) limit in order to provide future system enhancement with minimal infrastructure modifications.
7. Sequences: Submit a complete description of the operation of the control system, including sequences of operation. The description shall include and reference a schematic diagram of the controlled system. The wording of the control sequences in the submittal shall match verbatim that included in the construction documents to ensure there are no sequence deviations from that intended by the Architect/Engineer. Clearly highlight any deviations from the specified sequences on the submittals.

8. Points List Schedule: Submit a complete points list of all points to be connected to the TCS and FMCS. The points list for each system controller shall include both inputs and outputs (I/O), point number, the controlled device associated with the I/O point, the location of the I/O device, and reference drawings. Where a control point is the same as that shown on the control system schematic, label it with the same name. Points list shall specifically identify alarms, trends, event history, archive, totalization, graphic points, and all mapped points from other systems (security systems, lighting control, fire alarm, etc.). Provide points lists, point naming convention, and factory support information for systems provided and integrated into the FMCS.
9. Damper Schedule: Schedule shall include a separate line for each damper and a column for each of the damper attributes:

    a. Damper Identification Tag.
    b. Location.
    c. Damper Type.
    d. Damper Size.
    e. Duct Size.
    f. Arrangement.
    g. Blade Type.
    h. Velocity.
    i. Pressure Drop.
    j. Fail Position.
    k. Actuator Identification Tag.
    l. Actuator Type.
    m. Mounting.

10. Valve Schedule: Valve manufacturer shall size valves and create a valve schedule. Schedule shall include a separate line for each valve and a column for each of the valve attributes:

    a. Valve Identification Tag.
    b. Location.
    c. Valve Type.
    d. Valve Size.
    e. Pipe Size.
    f. Configuration.
    g. Flow Characteristics.
    h. Capacity.
    i. Valve C_V.
    j. Design Pressure Drop.
    k. Pressure Drop at Design Flow.
    l. Fail Position.
    m. Close-off Pressure.
    n. Valve and Actuator Model Number and Type.

11. Indoor modular air handling units (Section 23 73 13) and mixed flow return air fans (Section 23 34 13) provided under this project will have piezometer type sensors mounted at fan inlets by fan manufacturer. Fan manufacturer will provide fan specific flow coefficients and equations that can be used to calculate fan airflow based on measured pressure differential at fan inlet. TCC shall provide the following:

    a. Quantity of pressure transducers so that each individual fan is served by a dedicated pressure transducer. Each pressure transducer shall have a range that is selected based on scheduled maximum airflow for each fan. TCC shall submit a schedule that shows the following calculations for each fan/pressure transducer:

        1) Pressure drop at maximum scheduled airflow for each fan using fan manufacturer's flow coefficient.
        2) Recommended transducer range.

    b. Pneumatic tubing as required to interconnect all piezometer type sensors and pressure transducer. **Note: Where UV lamps are installed upstream of supply fan inlets, only copper tubing shall be used.**

c. Fasteners and supports as required to securely attached tubing, pressure transducers, conduits, wiring, and the like for a complete installation.

12. Airflow Measuring Station Schedule:

a. The manufacturer's authorized representative shall prepare the airflow measuring station submittal, or review and approve in writing the submittal prepared by the TCC prior to submission to the Architect/Engineer and prior to installation. The representative shall review air handling equipment submittals and duct fabrication drawings to ensure that all AFMS locations meet the appropriate parameters to achieve proper installation and the specified accuracy. Comply with all manufacturer's installation requirements including straight up and downstream duct lengths. Install airflow straighteners if required by the manufacturer based on installation constraints. The Architect/Engineer shall be notified for approval of any deviations.
b. Submit product data sheets for airflow measuring devices indicating minimum placement requirements, sensor density, sensor distribution, and installed accuracy to the host control system.
c. Submit installation, operation, and maintenance documentation.

13. Product Data Sheets: Required for each component that includes: unique identification tag that is consistent throughout the submittal, manufacturer's description, technical data, performance curves, installation/maintenance instructions, and other relevant items. When manufacturer's literature applies to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means. Each submitted piece of literature and drawings shall clearly reference the specification and/or drawing that the submittal is to cover. General catalogs shall not be accepted as cutsheets to fulfill submittal requirements.
14. Provide PICS files indicating the BACnet functionality and configuration of each device.
15. Provide documentation of submitted products that have been tested and listed by the BACnet Testing Laboratory (BTL), or provide a letter on the manufacturer's company letterhead indicating the anticipated date by which testing is expected to be completed. If, for any reason, BTL testing and listing has not been completed, a written commitment to upgrade installed controls to a version that meets BTL testing and listing requirements if problems are found during BTL testing is required.
16. Graphic Display: Include a sample graphic of each system and component identified in the points list with a flowchart (site map) indicating how the graphics are to be linked to each other for system navigation.
17. Software: A list of operating system software, operator interface software, color graphic software, and third-party software.
18. Control System Demonstration and Acceptance: Provide a description of the proposed process, along with all reports and checklists to be used.
19. Clearly identify work by others in the submittal.
20. Quantities of items submitted may be reviewed but are the responsibility of the Contractor to verify.

C. Operation and Maintenance Manual:

1. In addition to the requirements of Section 23 05 00, submit an electronic copy of the O&M manuals in PDF format.
2. Provide three complete sets of manuals.
3. Each O&M manual shall include:

a. Table of contents with indexed tabs dividing information as outlined below.
b. Definitions: List of all abbreviations and technical terms with definitions.
c. Warranty Contacts: Names, addresses, and 24-hour telephone numbers of contractors installing equipment and controls and service representatives of each.
d. Licenses, Guarantees, and Warranties: Provide documentation for all equipment and systems.
e. System Components: Alphabetical list of all system components, with the name, address, and telephone number of the vendor.

f. Operating Procedures: Include procedures for operating the control systems; logging on/off; enabling, assigning, and reporting alarms; generating reports; collection, displaying, and archiving of trended data; overriding computer control; event scheduling; backing up software and data files; and changing setpoints and other variables.
g. Programming: Description of the programming language (including syntax), statement descriptions (including algorithms and calculations used), point database creation and modification, program creation and modification, and use of the editor.
h. Engineering, Installation, and Maintenance: Explain how to design and install new points, panels, and other hardware; recommended preventive maintenance procedures for all system components, including a schedule of tasks (inspection, cleaning, calibration, etc.), time between tasks, and task descriptions; how to debug hardware problems; and how to repair or replace hardware. A list of recommended spare parts.
i. Original Software: Complete original issue CDs for all software provided, including operating systems, programming language, operator workstation software, and graphics software.
j. Software: One set of CDs containing an executable copy of all custom software created using the programming language, including the setpoints, tuning parameters, and object database.
k. Graphics: A glossary or icon symbol library detailing the function of each graphic icon and graphics creation and modification. One set of CDs containing files of all color graphic screens created for the project.

D. Training Manual:

1. Provide a course outline and training manuals for each training class.

E. Record Documents:

1. Submit record documentation per Section 23 05 00.
2. Provide a complete set of "as-built" drawings and application software on CDs. Provide drawings as AutoCAD™ or Visio™ compatible files. Provide two copies of the "as-built" drawings with revisions clearly indicated in addition to the documents on compact disk. All as-built drawings shall also be installed on the FMCS server in a dedicated directory. Provide all product data sheets in PDF format.
3. Submit two hard copies and one electronic copy of as-built versions of the shop drawings, including product data and record drawings with revisions clearly indicated. Provide floor plans showing actual locations of control components including panels, thermostats, sensors, and hardware.
4. Provide all completed testing and commissioning reports and checklists, along with all trend logs for each system identified in the points lists.
5. Submit printouts of all graphic screens with current values (temperatures, pressures, etc.) to the A/E verifying completion and proper operation of all points.

1.5 DELIVERY, STORAGE AND HANDLING

A. Provide factory-shipping cartons for each piece of equipment and control device. Maintain cartons through shipping, storage, and handling as required to prevent equipment damage. Store equipment and materials inside and protected from weather.

B. Factory-Mounted Components: Where control devices specified in this section are indicated to be factory mounted on equipment, arrange for shipping control devices to unit manufacturer.

1.6 PRODUCTS FURNISHED BUT NOT INSTALLED UNDER THIS SECTION

A. Control Valves.

B. Flow Switches.

C. Temperature Sensor Sockets.

D. Gauge Taps.

E. Automatic Dampers.

F. Flow Meters.

1.7 AGENCY AND CODE APPROVALS

A. All products shall have the following agency approvals. Provide verification that the approvals exist for all submitted products with the submittal package.

1. UL-916; Energy Management Systems.
2. C-UL listed to Canadian Standards Association C22.2 No. 205-M1983 "Signal Equipment."
3. EMC Directive 89/336/EEC (European CE Mark).
4. FCC, Part 15, Subpart J, Class A Computing Devices.

1.8 ACRONYMS

A. Acronyms used in this specification are as follows:

1. B-AAC BACnet Advanced Application Controller
2. B-ASC BACnet Application Specific Controller
3. BTL BACnet Testing Laboratories
4. DDC Direct Digital Controls
5. FMCS Facility Management and Control System
6. GUI Graphic User Interface
7. IBC Interoperable BACnet Controller
8. IDC Interoperable Digital Controller
9. LAN Local Area Network
10. NAC Network Area Controller
11. ODBC Open DataBase Connectivity
12. OOT Object Oriented Technology
13. OPC Open Connectivity via Open Standards
14. PICS Product Interoperability Compliance Statement
15. PMI Power Measurement Interface
16. POT Portable Operator's Terminal
17. TCC Temperature Control Contractor
18. TCS Temperature Control System
19. WAN Wide Area Network
20. WBI Web Browser Interface

1.9 SUMMARY

A. Provide new standalone FMCS for this project.

B. TCC shall furnish all labor, materials, equipment, and service necessary for a complete and operating Temperature Control System (TCS) and Facility Management and Control System (FMCS) using Direct Digital Controls as shown on the drawings and as described herein.

C. All labor, material, equipment and software not specifically referred to herein or on the plans that is required to meet the intent of this specification shall be provided without additional cost to the Owner.

D. The Owner shall be the named license holder of all software associated with any and all incremental work on the project.

E. Provide Critical Environment Control System (refer to Section 23 09 20

1.10 SYSTEM DESCRIPTION

A. The entire TCS shall be comprised of a network of interoperable, standalone digital controllers communicating via the following protocol to an NAC. Temperature Control System products shall be as specified below.

B. The FMCS shall include Network Area Controller or Controllers (NAC) within each facility. The NAC shall connect to the Owner's local or wide area network, depending on configuration. Provide access to the system, either locally in each building or remotely from a central site or sites, through standard Web browsers, via the Internet, and/or via local area network.

C. Provide materials and labor necessary to connect factory supplied control components.

D. Provide central and remote hardware, software, and interconnecting wire and conduit.

E. The FMCS shall include automated alarming software capable of calling e-mail compatible cellular telephones and pagers. The e-mail alarm paging system shall be able to segregate users, time schedules, and equipment and be capable of being programmed by the Owner.

F. For the dedicated configuration tool provided, it is preferable that it be launched from within the applicable Network Management Software. If not, include any software required for controller configuration as a leave-behind tool with enough license capability to support the installation.

G. For each operator workstation provided, furnish one legal copy of all software tools, configuration tools, management tools, and utilities used during system commissioning and installation. All tools shall be readily available in the market. Contractor shall convey to the Owner all software tools and their legal licenses at project closeout.

1.11 SOFTWARE LICENSE AGREEMENT

A. The Owner shall be the named license holder of all software associated with any and all incremental work on the project(s). In addition, the Owner shall receive ownership of all job-specific configuration documentation, data files, configuration tools, and application-level software developed for the project. This shall include, but is not limited to, all custom, job-specific software code and documentation for all configuration and programming that is generated for a given project and/or configured for use with the NAC, FMCS Server(s), and any related LAN/WAN/intranet and/or Internet connected routers and devices. Provide the Owner with all required IDs and passwords for access to any component or software program. The Owner shall determine which organizations shall be named in the SI organization ID ("orgid") of all software licenses. Owner shall be free to direct the modification of the "orgid" in any software license, regardless of supplier.

1.12 JOB CONDITIONS

A. Cooperation with Other Trades: Coordinate the Work of this section with that of other sections to ensure that the Work will be carried out in an orderly fashion. It is this Contractor's responsibility to check the Contract Documents for possible conflicts between the Work of this section and that of other crafts in equipment location; pipe, duct and conduit runs; electrical outlets and fixtures; air diffusers; and structural and architectural features.

1.13 WARRANTY

A. Refer to Section 23 05 00 for warranty requirements.

B. Within the warranty period, any defects in the work provided under this section due to faulty materials, methods of installation or workmanship shall be promptly (within 48 hours after receipt of notice) repaired or replaced by this Contractor at no expense to the Owner.

C. Warranty requirements include furnishing and installing all FMCS software upgrades issued by the manufacturer during the one-year warranty period.

D. Update all software and back-ups during warranty period and all user documentation on the Owner's archived software disks.

1.14 WARRANTY ACCESS

A. The Owner shall grant to this Contractor reasonable access to the TCS and FMCS during the warranty period.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. BACnet Protocol:

1. Johnson Controls: Metasys Extended Architecture - sole source

2.2 SYSTEM ARCHITECTURE

A. General:

1. The Temperature Control System (TCS) and Facility Management Control System (FMCS) shall consist of a network of interoperable, standalone digital controllers, a computer system, graphic user interface software, printers, network devices, valves, dampers, sensors, and other devices as specified herein.
2. The installed system shall provide secure password access to all features, functions and data contained in the overall FMCS.

B. Open, Interoperable, Integrated Architectures:

1. All components and controllers supplied under this Division shall be true "peer-to-peer" communicating devices. Components or controllers requiring "polling" by a host to pass data are not acceptable.
2. The supplied system must be able to access all data using standard Web browsers without requiring proprietary operator interface and configuration programs. An Open DataBase Connectivity (ODBC) or Structured Query Language (SQL) compliant server database is required for all system database parameter storage. This data shall reside on a supplier-installed server for all database access. Systems requiring proprietary database and user interface programs are not acceptable.
3. Hierarchical or "flat" topologies are required to have system response times as indicated below and to manage the flow and sharing of data without unduly burdening the customer's internal intranet network.

    a. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 5 seconds for network connected user interfaces.
    b. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 60 seconds for remote or dial-up connected user interfaces.

2.3 NETWORKS

A. The Local Area Network (LAN) shall be a 100 megabits/sec Ethernet network supporting BACnet, Java, XML, HTTP, and SOAP. Provide support for multiple Network Area Controllers (NACs), user workstations and, if specified, a local server.

B. Local area network minimum physical and media access requirements:

1. Ethernet; IEEE Standard 802.3.
2. Cable; 100 Base-T, UTP-8 wire, Category 6.
3. Minimum throughput; 100 Mbps.

C. Communication conduits shall not be installed closer than six feet from 110VAC or higher transformers or run parallel within six feet of electrical high-power cables. Route the cable as far from interference generating devices as possible. Where communication wire must cross 110VAC or higher wire, it must do so at right angles.

D. Ground all shields (earth ground) at one point only to eliminate ground loops. Provide all shield grounding at the controller location, with the shield at the sensor/device end of the applicable wire being left long and "safed" off in an appropriate manner.

E. There shall be no power wiring more than 30 VAC rms run in conduit with communications wiring. In cases where signal wiring is run in conduit with communication wiring, run all communication wiring and signal wiring using separate twisted pairs (24awg) in accordance with the manufacturer's wiring practices.

2.4 REMOTE NETWORK ACCESS

A. For Local Area Network installations, provide access to the LAN from a remote location via the Internet. The Owner shall provide a connection to the Internet to enable this access via high speed cable modem, asynchronous digital subscriber line (ADSL) modem, ISDN line, T1 Line or via the customer's intranet to a corporate server providing access to an Internet Service Provider (ISP). Customer agrees to pay monthly access charges for connection and ISP.

2.5 NETWORK AREA CONTROLLER (NAC)

A. The TCC shall supply one or more Network Area Controllers (NAC) as part of this contract. Number of NACs required depends on the type and quantity of devices provided under Divisions 23 and 26. The TCC shall determine the quantity and type of devices.

B. Each NAC shall provide the interface between the LAN or WAN and the field control devices and shall provide global supervisory control functions over the control devices connected to the NAC. It shall execute application control programs to provide:

1. Calendar functions.
2. Scheduling.
3. Trending.
4. Alarm monitoring and routing.
5. Time synchronization.
6. Integration of all controller data.
7. Network Management functions.

C. The Network Area Controller shall provide the following hardware features as a minimum:

1. One Ethernet Port - 10/100 Mbps.
2. One RS-232 port.
3. One LonWorks Interface Port - 78KB FTT-10A (for LonWorks systems only).
4. One RS-485 port.
5. Battery backup.

6. Flash memory for long-term data backup. (If battery backup or flash memory is not supplied, the controller shall contain a hard disk with at least 1 gigabyte storage capacity.)
7. The NAC must be capable of operation over a temperature range of 32°F to 122°F.
8. The NAC must be capable of withstanding storage temperatures of between 0°F and 158°F.
9. The NAC must be capable of operation over a humidity range of 5% RH to 95% RH, non-condensing.

D. The NAC shall provide multiple user access to the system and support for ODBC or SQL. Databases resident on the NAC shall be ODBC-compliant or must provide an ODBC data access mechanism to read and write data stored within it.

E. The NAC shall support standard Web browser access via the Internet or an intranet and a minimum of five (5) simultaneous users.

F. Event Alarm Notification and Actions:

1. The NAC shall provide alarm recognition, storage; routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers.
2. The NAC shall be able to route any alarm condition to any defined user location whether connected to a LAN, remote via dial-up telephone connection, or WAN.
3. Alarm generation shall be selectable for annunciation type and acknowledgement requirements including, but not limited to:

    a. Alarm
    b. Normal

4. Provide for the creation of a minimum of eight alarm classes with different routing and acknowledgement properties, e.g. security, HVAC, Fire, etc.
5. Provide timed (scheduled) routing of alarms by class, object, group, or node.
6. Provide alarm generation from binary object "runtime" and/or event counts for equipment maintenance. The user shall be able to reset runtime or event count values with appropriate password control.

G. Treat control equipment and network failures as alarms and annunciated.

H. Annunciate alarms in any of the following manners as defined by the user:

1. Screen message text.
2. E-mail of the complete alarm message to multiple recipients. Provide the ability to route and e-mail alarms based on:

    a. Day of week.
    b. Time of day.
    c. Recipient.

3. Pagers via paging services that initiate a page on receipt of e-mail message.
4. Graphic with flashing alarm object(s).
5. Printed message, routed directly to a dedicated alarm printer.

I. The FMCS shall record the following for each alarm:

1. Time and date.
2. Location (building, floor, zone, office number, etc.).
3. Equipment tag.
4. Acknowledge time, date, and user who issued acknowledgement.
5. Number of occurrences since last acknowledgement.

J. Give defined users proper access to acknowledge any alarm.

K. A log of all alarms shall be maintained by the NAC and/or a server (if configured in the system) and shall be available for review by the user.

L. Provide a "query" feature to allow review of specific alarms by user-defined parameters.

M. A separate log for system alerts (controller failures, network failures, etc.) shall be provided and available for review by the user.

N. An error log to record invalid property changes or commands shall be provided and available for review by the user.

2.6 BACNET FMCS

A. The intent of this specification is to provide a peer-to-peer networked, standalone, distributed control system with the capability to integrate ANSI/ASHRAE Standard 135-2001 BACnet, MODBUS, OPC, and other open and proprietary communication protocols in one open, interoperable system.

B. The supplied computer software shall employ object-oriented technology (OOT) for representation of all data and control devices in the system. Adherence to industry standards including the latest ANSI/ASHRAE Standard 135 (BACnet) to assure interoperability between all system components is required. For each BACnet device, the device supplier must provide a PICS document showing the installed device's compliance level. Minimum compliance is Level 3; with the ability to support data read and write functionality. Physical connection of BACnet devices shall be via Ethernet (BACnet Ethernet/IP) and/or RS-485 (BACnet MSTP).

C. Interoperable BACnet Controller (IBC):

1. Controls shall be microprocessor based Interoperable BACnet Controllers (IBC) in accordance with the latest ANSI/ASHRAE Standard 135. Provide IBCs for unit ventilators, fan coils, heat pumps, terminal air boxes (TAB) and other applications. The application control program shall reside in the same enclosure as the input/output circuitry that translates the sensor signals. Provide a PICS document showing the installed system's compliance level to ANSI/ASHRAE Standard 135. Minimum compliance is Level 3.
2. The IBCs shall be listed by the BACnet Testing Laboratory (BTL) as follows:

    a. BACnet Building Controller(s) (B-BC).
    b. BACnet Advanced Application Controller(s) (B-ACC).
    c. BACnet Application Specific Controller(s) (B-ASC).

3. The IBCs shall communicate with the NAC via an Ethernet connection at a baud rate of not less than 10 Mbps.
4. Each IBC sensor shall connect directly to the IBC and shall not use any of the I/O points of the controller. The IBC Sensor shall provide a two-wire connection to the controller that is polarity and wire type insensitive. The IBC sensor shall provide a communications jack for connection to the BACnet communication trunk to which the IBC controller is connected. The IBC sensor, the connected controller, and all other devices on the BACnet bus shall be accessible by the POT.
5. All IBCs shall be fully application programmable and shall at all times maintain their BACnet Level 3 compliance. Controllers offering application selection only (non-programmable) require a 10% spare point capacity to be provided for all applications. Store all control sequences within or programmed into the IBC in non-volatile memory that does not depend on a battery to be retained.
6. The Contractor supplying the IBCs shall provide documentation for each device, with the following information at a minimum:

    a. BACnet Device; MAC address, name, type and instance number.
    b. BACnet Objects; name, type and instance number.

7. It is the responsibility of the Contractor to ensure that the proper BACnet objects are provided in each IBC.

D. Object Libraries:

1. A standard library of objects shall be included for development and setup of application logic, user interface displays, system services, and communication networks.
2. The objects in this library shall be capable of being copied and pasted into the user's database and shall be organized according to their function. In addition, the user shall have the capability to group objects created in their application and store the new instances of these objects in a user-defined library.
3. In addition to the standard libraries specified here, the system supplier shall maintain an on-line accessible (over the Internet) library, available to all registered users, to provide new or updated objects and applications as they are developed.
4. All control objects shall conform to the control objects specified in the BACnet specification.
5. The library shall include applications or objects for the following functions, at a minimum:

    a. Scheduling Object: The schedule must conform to the schedule object as defined in the BACnet specification, providing seven-day plus holiday and temporary scheduling features and a minimum of 10 on/off events per day. Data entry to be by graphic sliders to speed creation and selection of on-off events.
    b. Calendar Object: The calendar must conform to the calendar object as defined in the BACnet specification, providing 12-month calendar features to allow for holiday or special event data entry. Data entry to be by graphic "point-and-click" selection. This object must be "linkable" to any or all scheduling objects for effective event control.
    c. Override Object: Provide override object that is capable of restarting equipment turned off by other energy saving programs to maintain occupant comfort or for equipment protection.
    d. Start-Stop Time Optimization Object: Provide a start-stop time optimization object to start equipment just early enough to bring space conditions to desired conditions by the scheduled occupancy time. Also, allow equipment to be stopped before the scheduled unoccupied time just far enough ahead to take advantage of the building's "flywheel" effect for energy savings. Provide automatic tuning of all start-stop time object properties based on historical performance.
    e. Demand Limiting Object: Provide a demand-limiting object that is capable of controlling demand for any selected energy utility (electric, oil, gas, etc.). The object shall be able to monitor a demand value and predict (using a sliding window prediction algorithm) the demand at the end of the user-defined interval period (1 to 60 minutes). This object shall also accommodate a utility meter time sync pulse for fixed interval demand control. Upon a prediction that will exceed the user-defined demand limit (supply a minimum of 6 per day), the demand limiting object shall issue shed commands to either turn off user specified loads or modify equipment setpoints to provide the desired energy reduction. If the list of sheddable equipment is not enough to reduce the demand to below the setpoint, display a message on the user's screen (as an alarm) instructing the user to take manual actions to maintain the desired demand. The shed lists are specified by the user and shall be selectable to be shed in either a fixed or rotating order to control which equipment is shed the most often. Upon suitable reductions in demand, the demand-limiting object shall restore the equipment that was shed in the reverse order in which it was shed. Each sheddable object shall have a minimum and maximum shed time property to provide both equipment protection and occupant comfort.

6. The library shall include control objects for the following functions:

    a. Analog Input Object: Minimum requirement is to comply with the BACnet standard for data sharing. Allow high, low and failure limits to be assigned for alarming. Also, provide a time delay filter property to prevent nuisance alarms caused by temporary excursions above or below the user defined alarm limits.
    b. Analog Output Object: Minimum requirement is to comply with the BACnet standard for data sharing.
    c. Binary Input Object: Minimum requirement is to comply with the BACnet standard for data sharing. The user must be able to specify either input condition for alarming. This object must also include the capability to record equipment runtime by counting the amount of time the hardware input is in an "on" condition. The user must be able to specify either input condition as the "on" condition.

d. Binary Output Object: Minimum requirement is to comply with the BACnet standard for data sharing. Properties to enable minimum on and off times for equipment protection as well as start-to-start delay must be provided. Incorporate the BACnet Command Prioritization priority scheme to allow multiple control applications to execute commands on this object with the highest priority command being invoked. Provide 16 levels of priority as a minimum. Systems not employing the BACnet method of contention resolution are not acceptable.
e. PID Control Loop Object: Minimum requirement is to comply with the BACnet standard for data sharing. Each individual property must be adjustable to allow proportional control only, or proportional with integral control, or proportional, integral and derivative control.
f. Comparison Object: Allow a minimum of two analog objects to be compared to select either the highest, lowest, or equality between the two linked inputs. Also, allow limits to be applied to the output value for alarm generation.
g. Math Object: Allow a minimum of four analog objects to be tested for the minimum or maximum, or the sum, difference, or average of linked objects. Also, allow limits to be applied to the output value for alarm generation.
h. Custom Programming Objects: Provide a blank object template for the creation of new custom objects to meet specific user application requirements. This object must provide a simple BASIC-like programming language that is used to define object behavior. Provide a library of functions including, but not limited to, math and logic functions and string manipulation. Also, provide a comprehensive on-line debug tool to allow complete testing of the new object. Allow new objects to be stored in the library for reuse.
i. Interlock Object: Provide an interlock object that provides a means of coordination of objects within a piece of equipment, such as an air handler or other similar types of equipment. An example is to link the return fan to the supply fan such that, when the supply fan is started, the return fan object is also started automatically without the user having to issue separate commands or to link each object to a schedule object. In addition, the control loops, damper objects, and alarm monitoring (such as return air, supply air, and mixed air temperature objects) will be inhibited from alarming during a user-defined period after startup to allow for stabilization. When the air handler is stopped, the interlocked return fan is also stopped, the outside air damper is closed, and other related objects within the air handler unit are inhibited from alarming, thereby eliminating nuisance alarms during the off period.
j. Temperature Override Object: Provide an object whose purpose is to override a binary output to an "on" state in the event a user-specified high or low limit value is exceeded. Link this object to the desired binary output object as well as to an analog object for temperature monitoring to cause the override to be enabled. This object will execute a start command at the Temperature Override level of start/stop command priority, unless changed by the user.
k. Composite Object: Provide a container object that allows a collection of objects representing an application to be encapsulated to protect the application from tampering or to more easily represent large applications. This object must have the ability to allow the user to select the appropriate parameters of the "contained" application that are represented on the graphic shell of this container.

7. The object library shall include objects to support the integration of devices connected to the Network Area Controller (NAC). Provide the following as part of the standard library included with the programming software:

a. LonMark/LonWorks Devices: These devices shall include, but not be limited to, devices for control of HVAC, lighting, access, and metering. Provide LonMark manufacturer-specific objects to facilitate simple integration of these devices. Support all network variables defined in the LonMark profile. The device manufacturer shall provide information (type and function) regarding network variables not defined in the LonMark profile.
b. For devices not conforming to the LonMark standard, provide a dynamic object that can be assigned to the device based on network variable information provided by the device manufacturer. Device manufacturer shall provide an XIF file, resource file, and documentation for the device to facilitate device integration.
c. For BACnet devices, provide the following objects:

1) Analog In.
2) Analog Out.
3) Analog Value.
4) Binary.
5) Binary In.

6) Binary Out.
7) Binary Value.
8) Multi-State In.
9) Multi-State Out.
10) Multi-State Value.
11) Schedule Export.
12) Calendar Export.
13) Trend Export.
14) Device.

d. For each BACnet object, provide the ability to assign the object a BACnet device and object instance number.
e. For BACnet devices, provide the following support at a minimum:

1) Segmentation.
2) Segmented Request.
3) Segmented Response.
4) Application Services.
5) Read Property.
6) Read Property Multiple.
7) Write Property.
8) Write Property Multiple.
9) Confirmed Event Notification.
10) Unconfirmed Event Notification.
11) Acknowledge Alarm.
12) Get Alarm Summary.
13) Who-has.
14) I-have.
15) Who-is.
16) I-am.
17) Subscribe COV.
18) Confirmed COV notification.
19) Unconfirmed COV notification.
20) Media Types.
21) Ethernet.
22) BACnet IP Annex J.
23) MSTP.
24) BACnet Broadcast Management Device (BBMD) function.
25) Routing.

2.7 TERMINAL AIR BOX (TAB) CONTROLLERS

A. FMCS Volume Controller: Electronic, furnished and installed by TCC. Boxes shall have pressure independent control to maintain constant air volume regardless of duct pressure changes up to 6 inches w.c. and shall be accurate down to 0.004" velocity pressure. Provide velocity and static sensor at box inlet for use by unit controller. Set boxes for maximum and minimum settings shown on the drawings. Refer to Section 23 36 00 for additional information.

B. The controller shall support various digital and analog inputs and outputs as needed for damper control, control valves, electric coils, airflow sensors, remote heating, occupancy sensors, etc. and shall be capable of independent occupancy scheduling.

C. Controller shall provide continuous zone temperature histories internal to device for up to 24 hours and perform its own limit and status monitoring and alarms to limit unnecessary communications.

D. Operator interface to any ASC point data or programs shall be through network resident programs or portable operator's terminal connected to the specific controller.

E. Store all system setpoints, proportional bands, control algorithms, and other programmable parameters such that a power failure of any duration does not necessitate reprogramming of the controller.

F. BACnet TAB controllers shall either be B-AAC devices or B-ASC devices as required to meet the performance and BTL listing.

2.8 DATA COLLECTION AND STORAGE (TRENDING REQUIREMENTS)

A. The NAC shall be able to collect data for any property of any object and store resident in the NAC that shall have, at a minimum, the following configurable properties:

1. Designating the log as interval or deviation.
2. For interval logs, configure the object for time of day, day of week and the sample collection interval.
3. For deviation logs, configure the object for the deviation of a variable to a fixed value. This value, when reached, will initiate logging of the object.
4. For all logs, provide the ability to set the maximum number of data stores for the log and to set whether the log will stop collecting when full or rollover the data on a first-in, first-out basis.
5. Each log shall have the ability to have its data cleared on a time-based event or by a user-defined event or action.

B. Store all log data in a relational database in the NAC that is accessible from a server (if the system is so configured) or a standard Web browser.

C. All log data, when accessed from a server, shall be capable of being manipulated using standard SQL statements.

D. All log data shall be available to the user in ALL the following data formats:

1. HTML.
2. XML.
3. Plain text.
4. Comma or tab separated values.

E. The NAC shall archive its log data either locally (to itself) or remotely to a server or other NAC on the network. Provide the ability to configure the following archiving properties:

1. Archive on time of day.
2. Archive on user-defined number of data stores in the log (buffer size).
3. Archive when log has reached its user-defined capacity of data stores.
4. Provide ability to clear logs once archived.

2.9 AUDIT LOG

A. Provide and maintain an audit log that tracks all activities performed on the NAC. Provide the ability to specify a buffer size for the log and the ability to archive log based on time or when the log has reached its user-defined buffer size. Provide the ability to archive the log locally (to the NAC), to another NAC on the network, or to a server. For each log entry, provide the following data:

1. Time and date.
2. User ID.
3. Change or activity: i.e., change setpoint, add or delete objects, commands, etc.

2.10 DATABASE BACKUP AND STORAGE

A. The NAC shall automatically backup its database on a user-defined time interval.

B. Store copies of the current database and, at the most, the recently saved database in the NAC. The age of the most recently saved database shall depend on the user-defined database save interval.

C. Store the NAC database in XML format to allow viewing and editing. Other formats are acceptable as long as XML format is supported.

2.11 GRAPHIC USER INTERFACE SOFTWARE

A. Operating System:

1. Provide computer with the most current Microsoft-based operating system with which the GUI has proven compatibility.

B. The GUI shall employ browser-like functionality for ease of navigation. It shall include a tree view (similar to Windows Explorer) for quick viewing of, and access to, the hierarchical structure of the database. In addition, menu pulldowns and toolbars shall employ buttons, commands and navigation to permit the operator to perform tasks with basic computing skills. These shall include, but are not limited to, forward/backward buttons, home button, and a context sensitive locator line (similar to a URL line) that displays the location and the selected object identification.

C. Point Organization: Organize points by equipment categories, location, or other means acceptable to Owner.

D. Real-Time Displays: The GUI shall support the following graphic features and functions:

1. Graphic screens shall be developed using any drawing package capable of generating a GIF, BMP, or JPG file. Use of proprietary graphic file formats is not acceptable. In addition to, or in lieu of, a graphic background, the GUI shall support the use of scanned pictures.
2. Graphic screens shall be able to contain objects for text, real-time values, animation, color spectrum objects, logs, graphs, HTML or XML document links, schedule objects, hyperlinks to other URLs, and links to other graphic screens.
3. Graphics shall support layering, and each graphic object shall be configurable for assignment to a layer. A minimum of six layers shall be supported.
4. Modifying common application objects, such as schedules, calendars, and setpoints, shall be accomplished graphically.

   a. Schedule times shall be adjusted using a graphic slider without requiring any keyboard entry from the operator.
   b. Holidays shall be set by using a graphic calendar without requiring any keyboard entry from the operator.

5. Commands to start and stop binary objects shall be made by selecting the object and the appropriate command from a pop-up menu. No text entry shall be required.
6. Adjustments to analog objects, such as setpoints, shall be made by selecting the object and using a graphic slider to adjust the value. No text entry shall be required.

E. System Configuration: At a minimum, the GUI shall include the necessary software and components to enable the operator to perform the following tasks with proper password access:

1. Create, delete or modify control strategies.
2. Add/delete objects.
3. Tune control loops by adjusting control loop parameters.
4. Enable or disable control strategies.
5. Generate hard copy records or control strategies on a printer.
6. Select alarm points and define the alarm state.
7. Select points to be trended and initiate the recording of values automatically.
8. View any trend as a graph.

F. On-Line Help: Provide a context sensitive, on-line help system to assist the operator in operation and editing of the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available using hypertext. All system documentation and help files shall be in HTML format.

G. Security: Each operator shall be required to log on to that system with a user name and password to view, edit, add, or delete data. System security shall be selectable for each operator. The system administrator shall be able to set passwords and security levels for all other operators. Each operator password shall be able to restrict the operator's access for viewing and/or changing each system application, full screen editor, and object. Each operator shall be automatically logged off the system if no keyboard or mouse activity is detected. This auto log-off time shall be set per operator password. Store all system security data in an encrypted format.

H. System Diagnostics: The system shall automatically monitor the operation of all workstations, printers, modems, network connections, building management panels, and controllers. Annunciate the failure of any device to the operator.

I. Alarm Console:

1. The system shall have a dedicated alarm window or console. This window will notify the operator of an alarm condition, and allow the operator to view details of the alarm and to acknowledge the alarm.
2. When the alarm console is enabled, a separate alarm notification window will supersede all other windows on the desktop and shall not be capable of being minimized or closed by the operator. This window will notify the operator of new alarms and un-acknowledged alarms. Alarm notification windows or banners that can be minimized or closed by the operator are not acceptable. The use of the alarm console can be enabled or disabled by the system administrator.

2.12 WEB BROWSER CLIENTS

A. The system shall be capable of supporting an unlimited number of clients using a standard Web browser such as Internet Explorer™, Firefox™, or Chrome. Systems requiring additional software to enable a standard Web browser to reside on the client machine, or manufacturer-specific browsers, are not acceptable.

B. The Web browser shall provide the same view of the system, in terms of graphics, schedules, calendars, logs, etc., and provide the same interface methodology as is provided by the Graphic User Interface. Systems that require different views or that require different means of interacting with objects, such as schedules or logs, are not permitted.

C. The Web browser client shall provide:

1. User log-on identification and password shall be required. If an unauthorized user attempts access, display a blank web page. Implement security using Java authentication and encryption techniques to prevent unauthorized access.
2. Graphic screens developed for the GUI shall be the same screens used for the Web browser client. The web browser interface shall support all animated graphic objects supported by the GUI.
3. HTML programming shall not be required to display system graphics or data on a Web page. HTML editing of the Web page shall be allowed if the user desires a specific look or format.
4. Store all graphic screens in the Network Area Controller (NAC) without requiring any graphics storage on the client machine.
5. Real-time values displayed on a Web page shall update automatically without requiring a manual "refresh" of the Web page.
6. Users shall have administrator-defined access privileges. Depending on the access privileges assigned, the user shall be able to perform the following:

   a. Modify common application objects, such as schedules, calendars, and setpoints, graphically.

      1) Schedule times shall be adjustable using a graphic slider, without requiring any keyboard entry from the operator.
      2) Holidays shall be set using a graphic calendar, without requiring any keyboard entry from the operator.

b. Commands to start and stop binary objects shall be made by right-clicking the selected object and selecting the appropriate command from a pop-up menu. No text entry shall be required.
c. View logs and charts.
d. View and acknowledge alarms.
e. Setup and execute SQL queries on log and archive information

7. The system shall be able to specify a user's (as determined by the log-on user identification) home page. Provide the ability to limit a specific user to just his/her defined home page. From the home page, links to other views or pages in the system shall be possible, if allowed by the system administrator.
8. Graphic screens on the Web Browser client shall support hypertext links to other locations on the Internet or on intranet sites by specifying the Uniform Resource Locator (URL) for the desired link.

2.13 SERVER FUNCTIONS AND HARDWARE

A. Provide a central server located at Basement Mechanical Room. The server shall support all NACs connected to the customer's network whether local or remote.

B. Local connections shall be via an Ethernet LAN. Remote connections can be via ISDN, ADSL, T1, or dial-up connection.

C. It shall be possible to provide access to all NACs via a single connection to the server. In this configuration, each NAC can be accessed from a remote GUI or from a standard WBI by connecting to the server.

D. The server shall provide the following functions:

1. Global Data Access: The server shall provide complete access to distributed data defined anywhere in the system.
2. Distributed Control: The server shall provide the ability to execute global control strategies based on control and data objects in any NAC in the network, local or remote.
3. The server shall include a master clock service for its subsystems and provide time synchronization for all NACs.
4. The server shall accept time synchronization messages from trusted precision atomic clock Internet sites and update its master clock based on this data.
5. The server shall provide scheduling for all Network Area Controllers and their underlying field control devices.
6. The server shall provide demand limiting that operates across all NACs. The server must be capable of running multiple demand programs for sites with multiple meters and/or multiple sources of energy. Each demand program shall be able to support separate demand shed lists.
7. The server shall implement the BACnet Command Prioritization scheme (16 levels) for safe and effective contention resolution of all commands issued to NACs.
8. Each NAC supported by the server shall be able to automatically archive its log data, alarm data and database to the server. Archiving options shall be user-defined, including archive time and archive frequency.
9. The server shall provide central alarm management for all NACs supported by the server. Alarm management shall include:

   a. Routing alarms to display, printer, e-mail, and pagers.
   b. Viewing and acknowledging alarms.
   c. Querying alarm logs based on user-defined parameters.

10. The server shall provide central management of log data for all NACs supported by the server. Log data shall include process logs, runtime and event counter logs, audit logs and error logs. Log data management shall include:

    a. Viewing and printing log data.
    b. Exporting log data to other software applications.
    c. Querying log data based on user-defined parameters.

11. Reports shall be generated automatically or manually, and directed to LCD displays, printers, or disk files. The system shall allow the user to easily obtain the following types of reports:

    a. List all points in network.
    b. List all points in alarm.
    c. List all off-line points.
    d. List all points in override status.
    e. List all disabled points.
    f. List all points that are locked out.
    g. List all items defined in a "follow-up" file.
    h. List all weekly and holiday schedules.
    i. List all limits and deadbands.

E. Server Hardware Requirements:

1. Provide a High-Mid Range CPU as defined by www.cpubenchmark.net (minimum processing speed of 2.9 GHz with 8.0 GB RAM and a 1-terabyte minimum hard drive). It shall include one parallel port, one asynchronous serial port and four USB ports. Include a 21" minimum flat panel color monitor, 8ms response time.
2. The server operating system shall be the latest version of Microsoft Windows and Microsoft internet browser.
3. Connect to the FMCS network via an Ethernet network interface card, 1 Gbps.
4. Provide a color laser printer with a minimum 600 x 600-dpi resolution and 12 ppm print speed.
5. For dedicated alarm printing, provide a continuous feed printer using roll or fan-fed microperforated paper. The printer shall have a parallel port interface.

2.14 GRAPHIC USER INTERFACE COMPUTER HARDWARE (DESKTOP)

A. Provide a browser workstation with a High-Mid Range CPU as defined by www.cpubenchmark.net with 8.0 GB RAM and a 1 terabyte minimum hard drive. It shall include one parallel port, one asynchronous serial port and six USB ports. Include a 21" minimum flat panel color monitor, 8ms response time.

B. The workstation operating system shall be the latest version of Microsoft Windows and Microsoft internet browser.

C. Connect to the FMCS network via a 1 Gbps Ethernet network interface card.

D. Provide a color laser printer with minimum 600 x 600-dpi resolution and 12 PPM print speed.

2.15 UNINTERRUPTIBLE POWER SUPPLY (UPS)

A. A UPS shall be provided for each of the following:

1. FMCS workstations and servers.
2. Network area controllers.
3. Chiller plant manager.
4. Boiler plant manager.

B. Provide a 120-volt 60 Hz line-interactive uninterruptible power supply with backup battery capacity for 5 minutes at 100% load. UPS shall have hot swappable batteries, automatic battery self-test and start-on-battery capabilities. Batteries shall be valve regulated, sealed lead acid type. UPS shall have sine wave shape output waveform. UPS shall be UL 1778 list and comply with FCC Part 15, Class A.

C. Manufacturers:

1. Sola/Hevi-Duty
2. Eaton Powerware
3. APC

2.16 SYSTEM PROGRAMMING

A. The GUI software shall perform system programming and graphic display engineering. Access to the GUI software shall be through password access as assigned by the system administrator.

B. Provide a library of control, application, and graphic objects to enable creation of all applications and user interface screens. Applications shall be created by selecting the control objects from the library, dragging or pasting them on the screen, and linking them together using a built-in graphic connection tool. Completed applications may be stored in the library for future use. GUI screens shall be created in the same fashion. Data for the user displays shall be obtained by graphically linking the user display objects to the application objects to provide "real-time" data updates. Any real-time data value or object property may be connected to display its current value on a user display. Provide all software tools or processes to create applications and user interface displays.

C. Programming Methods:

1. Provide the capability to copy objects from the supplied libraries or from a user-defined library to the user's application. Link objects with a graphic linking scheme by dragging a link from one object to another. Object links will support one-to-one, many-to-one, or one-to-many relationships. Linked objects shall maintain their connections to other objects regardless of where they are positioned on the page and shall show link identification for links to objects on other pages for easy identification. Links will vary in color depending on the type of link; e.g., internal, external, hardware, etc.
2. Configuration of each object shall be done through the object's property sheet using fill-in-the-blank fields, list boxes, and selection buttons. Use of custom programming, scripting language, or a manufacturer-specific procedural language for configuration is not acceptable.
3. The software shall provide the ability to view the logic in a monitor mode. When on-line, the monitor mode shall provide the ability to view the logic in real time for easy diagnosis of the logic execution. When off-line (debug), the monitor mode shall allow the user to set values to inputs and monitor the logic for diagnosing execution before it is applied to the system.
4. All programming shall be done in real time. Systems requiring the uploading, editing, and downloading of database objects are not allowed.
5. The system shall support object duplication in a customer's database. An application, once configured, can be copied and pasted for easy reuse and duplication. All links, other than to the hardware, shall be maintained during duplication.

2.17 DDE DEVICE INTEGRATION

A. The NAC shall support the integration of device data via Dynamic Data Exchange (DDE) over the Ethernet network. The NAC shall act as a DDE client to another software application that functions as a DDE server.

B. Provide the required objects in the library included with the Graphic User Interface programming software to support the integration of these devices into the FMCS. Objects provided shall include, at a minimum:

1. DDE Generic AI Object.
2. DDE Generic AO Object.
3. DDE Generic BO Object.
4. DDE Generic BI Object.

2.18 MODBUS SYSTEM INTEGRATION

A. The NAC shall support integration of device data from Modbus RTU, ASCII, and TCP control system devices. Connect to the Modbus system via an RS-232, RS485, or Ethernet IP as required by the device.

B. Provide the required objects in the library included with the GUI programming software to support the integration of the Modbus system data into the FMCS. Objects provided shall include, at a minimum:

1. Read/Write Modbus AI Registers.

2. Read/Write Modbus AO Registers.
3. Read/Write Modbus BI Registers.
4. Read/Write Modbus BO Registers.

C. The NAC shall perform all scheduling, alarming, logging and global supervisory control functions of the Modbus system devices.

D. The FMCS supplier shall provide a Modbus system communications driver. The equipment system vendor that provided the equipment using Modbus shall provide documentation of the system's Modbus interface and shall provide factory support at no charge during system commissioning.

2.19 SOFTWARE

A. IDC/IBCs shall operate totally standalone and independent of a central computer for all specified control applications.

B. Software shall include a complete operating system (OS), communications handler, point processing, energy management application packages as specified herein, standard control algorithms and specific control sequences (IDC/IBC) and an Owner/user custom control calculation package complete with interpreter.

C. OS software shall be PROM resident, operate in real time, provide prioritized task scheduling, control time programs, monitor and manage communications, and scan inputs and outputs.

D. Each IDC/IBC panel shall include the following energy management routines:

1. Time of day scheduling.
2. Optimum start/stop.
3. Peak demand limiting.
4. Economizer control.
5. PID control.
6. Supply air reset.
7. Outdoor air reset.

E. Input/output point processing software shall include:

1. Update of all connected input and output points at least once per second.
2. Analog to digital conversion, scaling and offset, correction of sensor non-linearity, sensing no response or failed sensors, and conversion of values to 32-bit floating point format. Retain both the maximum and minimum values sensed for each analog input in memory. It shall be possible to input subsets of standard sensor ranges to the A/D converter and assign gains to match the full-scale 32-bit conversion to achieve high accuracy readout.
3. A reasonability check on all analog inputs against previous values and discarding of values falling outside preprogrammed reasonability limits.
4. Assignment of proper engineering units and status conditions to all inputs and outputs.
5. Analog input alarm comparison with the ability to assign two individual sets of high and low limits (warning and alarm) to an input or to assign a set of floating limits (alarm a reset schedule or FMCS control point) to the input. Assign each alarm a unique differential to prevent a point from oscillating in and out of alarm. Make alarm comparisons of each scan cycle.
6. Adjustment of timing from two seconds to two minutes in one-second increments to eliminate nuisance alarms on startup.

F. Command Control software shall manage the receipt of commands from the server and from control programs.

1. Provide command delay to prevent simultaneous energizing of loads. Delay must be programmable from 0 to 30 seconds.

2. Assign each command a command and residual priority to manage conflicts created by multiple programs having access to the same command point. Allow only outputs with a higher command priority to execute. Whenever a command is allowed to execute, its assigned residual priority shall replace the existing residual priority.
3. A "fixed mode" option (override) shall allow inputs to and outputs from control programs to set to a fixed state or value. When in the "fixed mode", assign inputs and outputs high residual command priority to prevent override by application programs.

G. Alarm lockout software shall prevent nuisance alarms. On initial start-up of mechanical equipment, assign a "timed lockout" period to analog points to allow them to reach a stable condition before activating alarm comparison logic. Lockout period shall be programmable for each point from 0 to 90 minutes in one-minute increments.

H. A "hard lockout" shall also be provided to positively lock out alarms when equipment is turned off or when a true alarm depends on the condition of an associated point. Hard lockout points and lockout initiators shall be operator programmable.

I. Runtime shall be accumulated based on the status of a digital input point. It shall be possible to totalize either on time or off time up to 10,000 hours with one-minute resolution. Runtime counts shall reside in non-volatile memory and have DCP resident runtime limits assignable through the operator's terminal.

J. A transition counter shall count the number of times a device is cycled on or off. Counter shall be non-volatile and capable of counting 600,000 cycles. Limits shall be assignable to counts to provide maintenance alarm printouts.

K. Custom IDC/IBC programs shall meet the control strategies called for in the sequence of operation of these specifications. Each IDC/IBC shall have resident in its memory and available to the programs a full library of IDC/IBC algorithms, intrinsic control operators, arithmetic, logic, and relational operators. Provide the following features:

1. Proportional Control, Proportional plus Integral (PI), Proportional plus Integral plus Derivative (PID), and Adaptive Control (self-learning). Use Adaptive Control where the controlled flow rate is variable (such as TAB units and variable flow pumping loops). The adaptive control algorithm shall monitor the loop response to output corrections and adjust the loop response characteristics in accordance with the time constant changes imposed by variable flow rates. The algorithm shall operate in a continuous self-learning manner and shall retain in memory a stored record of the system dynamics so that, on system shutdown and restart, the learning process starts from where it left off. Standard PID algorithms are not acceptable substitutes for variable flow applications since they will provide satisfactory control at only one flow rate and will require continued manual fine tuning.
2. All IDC/IBC setpoints, gains and time constants associated with IDC/IBC programs shall be available to the operator for display and modification via the operator workstation.
3. The execution interval of each IDC/IBC loop shall be adjustable from 2 to 120 seconds in one-second increments.
4. IDC/IBC control programs shall assign initialization values to all outputs so controlled devices assume a failsafe position on start-up.

L. Provide time and event programming (TEP) capability to initiate a controlled sequence of events for execution at a specific time or upon the occurrence of an event. Minimum program features required are:

1. Analog points commandable to a specific value.
2. Digital points commandable to a specific state; e.g. on or off; fast, slow or off.
3. Initiator to be a specific day and time or a specific event; e.g. an alarm.
4. Manual initiation via operator's command.
5. Commands must honor command delays (to prevent current surges), and assigned minimum ON and OFF times.
6. Commands must honor command and residual priority structures allowing higher priority commands (like smoke control) to override lower priority commands (like time of day scheduling) and residual priority.
7. Ability to chain TEPs.
8. Ability to enable and disable TEPs individually.
9. Ability to enable/disable TEP initiators.

M. Store Energy Management application programs and associated data files in non-volatile or 72-hour battery backed RAM memory. Individual programs shall be accessible from the operator workstation for enabling/disabling and program parameter modification and shall include:

1. Time Programs:

a. Provide an independent start and stop program time for each system identified in the points list.
b. It shall be possible to assign two independent start and stop times/days to any equipment connected to a controller.

2. Exception Day Scheduling:

a. Provide an Exception Day program for holiday and other planned exceptions to time programs. Exception schedules shall be DSC resident and operator programmable up to one year in advance.
b. The program shall allow definition of up to 32 exception time spans. Define each span by calendar start day and calendar stop day.

3. An IDC/IBC resident temporary scheduler shall allow operators to modify present time program control of equipment. Minimum feature set required is:

a. Ability to alter time schedules as much as six days in advance.
b. Ability to alter either start time, stop time or both for each day.
c. Temporary schedule shall be in effect for all days specified.
d. Automatically delete the temporary schedule and restore program to normal schedule after execution.
e. Ability to assign schedule changes as permanent as well as temporary.

N. The IDC/IBC shall have built-in, non-descriptive, self-test procedure for checking the indication lights, digital display, and memory. It shall display advisories for maintenance, performance, and/or software problems.

O. All electronics shall be:

1. Standard locally stocked modular boards.
2. Plug-in type.
3. Furnish all ROM programs unlocked.

2.20 CONTROL DAMPERS

A. Rectangular Control Dampers - Standard Construction:

1. Shall be licensed to bear the AMCA Certified Rating Seal.
2. Test leakage and pressure drop per AMCA 500.
3. Frame: Hat-shaped channel, minimum 12 gauge extruded aluminum, and minimum 4" deep. Caulk or weld seams to prevent leakage.
4. Blades: Minimum 12 gauge extruded aluminum airfoil design, minimum 6" wide, and overlapping blades and blade seals (overlapping blade seals only is unacceptable).
5. Shaft: Non-cylindrical, solid stainless steel with opening in blade to match profile of shaft. Shaft shall be securely fastened to the blade and of sufficient length to mount direct-coupled actuator. Damper manufacturer shall provide drive pin extensions and outboard bearing support brackets as required.
6. Bearings: Acetal (Delrin/Celcon) inner bearing fixed to an aluminum shaft, rotating within a polycarbonate outer bearing inserted in the frame. Provide thrust bearings for vertical damper applications.
7. Blade Seals: Extruded silicone gaskets secured in an integral slot within the blade.
8. Side Seals: Stainless steel compression type or extruded silicone gasket secured in an integral slot within the frame.

9. Linkage: Shall be concealed in the frame, constructed of aluminum or corrosion-resistant zinc plated steel, and securely fastened to shaft. Blades linked for opposed operation, unless noted otherwise on the drawings. Blades shall close evenly. Use one direct-coupled actuator per damper section. Jack-shafting is not acceptable.
10. Size Limits: 48" maximum horizontal blade length, 24 square foot maximum area per damper. Total cross-sectional area of dampers in ducts shall be at least as large as the duct without the use of blank-off sections.
11. Maximum Leakage: Class 1A at 1" w.c. pressure differential for a 24" x 24" damper.
12. Maximum Pressure Drop for Opposed Blade Damper: 0.15" for 8,000 cfm through a 24" x 24" damper (2000 fpm).
13. Maximum Pressure Drop for Parallel Blade Damper: 0.08" for 8,000 cfm through a 24" x 24" damper (2000 fpm).

B. Thermally Insulated Control Damper:

1. Shall be licensed to bear the AMCA Certified Rating Seal.
2. Test leakage and pressure drop per AMCA 500.
3. Thermally Broken Frame: Extruded aluminum, minimum 4" deep, 0.080" minimum thickness, flanged to duct. Entire frame shall be thermally broken using polyurethane resin pockets, complete with thermal cuts.
4. Blades: Minimum 12 gauge extruded aluminum airfoil design, minimum 6" wide, internally insulated with expanded polyurethane foam and thermally broken, with overlapping blades and blade seals (overlapping blade seals only is unacceptable).
5. Shaft: Non-cylindrical, solid stainless steel shaft with opening in blade to match profile of shaft. Shaft shall be securely fastened to the blade and of sufficient length to mount direct-coupled actuator. Damper manufacturer shall provide drive pin extensions and outboard bearing support brackets as required.
6. Bearings: Acetal (Delrin/Celcon) inner bearing fixed to an aluminum shaft, rotating within a polycarbonate outer bearing inserted in the frame. Provide thrust bearings for vertical damper applications.
7. Side Seals: Stainless steel compression type or extruded silicone gasket secured in an integral slot within the frame.
8. Linkage: Shall be concealed in the frame, constructed of aluminum or corrosion-resistant zinc plated steel, and securely fastened to shaft. Blades linked for opposed operation, unless noted otherwise on the drawings. Blades shall close evenly. Use one direct-coupled actuator per damper section. Jack-shafting is not acceptable.
9. Size Limits: 48" maximum horizontal blade length, 24 square foot maximum area per damper. Total cross-sectional area of dampers in ducts shall be at least as large as the duct without the use of blank-off sections.
10. Maximum Leakage: Class 1A at 1" w.c. pressure differential for a 24" x 24" damper.
11. Maximum Pressure Drop: 0.21" for 8,000 cfm through a 24" x 24" damper (2000 fpm).

C. Round Galvanized Steel Control Dampers:

1. Test leakage and pressure drop per AMCA 500.
2. Frame: Minimum 20 gauge galvanized steel, 10" long.
3. Bearings: Provide thrust bearings for vertical damper applications.
4. Blades: Two-layer galvanized steel, equivalent 14 gauge thickness with neoprene or polyethylene foam seal enclosed in two-piece blade construction up to 24", 10 gauge steel over 24".
5. Linkage: Stainless steel, minimum 1/2" diameter shaft through 24", 3/4" shaft over 24" size. Stainless steel bearings. Shaft shall be securely keyed to blades and of sufficient length to mount direct-coupled actuator. Install damper with the shaft horizontal to the floor. Damper manufacturer shall provide drive pin extensions and outboard bearing support brackets as required.
6. Maximum Leakage: 8 cfm maximum at 1" w.c. pressure differential for a 24" x 24" damper.
7. Maximum Pressure Drop: 0.10" for 6,280 cfm through a 24" damper (2,000 fpm).

D. Round Stainless Steel Control Dampers:

1. Test leakage and pressure drop per AMCA 500.
2. Frame: Hat-shaped channel, minimum 10 gauge Type 304 stainless steel (304L or 316L for welded duct). Caulk or weld seams to prevent leakage.

3. Bearings: Provide thrust bearings for vertical damper applications.
4. Blades: Minimum 12 gauge Type 304 stainless steel construction. No seals are required.
5. Linkage: Stainless steel, minimum 1/2" diameter shaft through 12", 3/4" shaft through 24", 1" shaft over 24" size. Stainless steel bearings. Shaft shall be securely keyed to blades and of sufficient length to mount direct-coupled actuator. Install damper with the shaft horizontal to the floor. Damper manufacturer shall provide drive pin extensions and outboard bearing support brackets as required.
6. Maximum Leakage: 26 cfm maximum at 1" w.c. pressure differential for a 24" x 24" damper.
7. Maximum Pressure Drop: 0.15" for 6,280 cfm through a 24" damper (2,000 fpm).

2.21 DAMPER ACTUATORS

A. Damper Actuators - Electronic:

1. Actuator shall be UL 873 or 60730 listed and provided with NEMA housing for applicable environment, electronic overload protection to prevent actuator damage due to over-rotation. Mount actuator by means of a V-bolt dual nut clamp with a V-shaped toothed cradle, directly couple and mount to the valve bonnet stem, or ISO-style direct-coupled mounting pad. Actuators shall be capable of being mechanically and electrically paralleled to increase torque, if required.
2. Actuators shall be warranted for a period of five (5) years from the date of production, with the first two (2) years unconditional.
3. Proportional actuator position shall be proportional to analog or pulse width modulating signal from electronic control system.
4. Fail-Safe Dampers: Where shown on the drawings or sequences, fail-safe mechanism shall operate the damper to the fail position following power interruption.

    a. Mechanical/Spring: Mechanical spring return mechanism to drive controlled drive to an end position (open or close) on loss of power.
    b. Electronic: Electronic fail-safe shall incorporate an active balancing circuit to maintain equal charging rates among the capacitors. The power fail position shall be proportionally adjustable between 0 to 100% in 10 percent increments with a 10 second operational delay.
5. Feedback: Where shown on drawings or sequences, provide analog feedback signal for positive position indication.
6. Damper End Switches: Where shown on the drawings or sequences, provide end switches to prove damper reaches open/closed position.

2.22 HYDRONIC CONTROL VALVES

A. General:

1. Two-position valves shall be a minimum of line size with a maximum allowable pressure drop of 1 psi.
2. Size two-way and three-way modulating valves to provide a pressure drop at full flow of 4 to 5 psi, except boiler three-way and cooling tower bypass valves shall not have a pressure drop over 4 psi.
3. Modulating two-way valves shall have equal percentage flow characteristics.
4. Modulating three-way valves shall have linear flow characteristics.
5. Piping geometry correction factors for C_v ratings shall be used and stated for ball valves, butterfly valves, or non-characterized valves.

B. Two-position:

1. Ball 2" and under:

    a. Design Pressure: 400 psi

        1) Design Temperature: 212°F
        2) Design Flow Differential Pressure Rating: 150 psi

b. Bronze or brass body, stainless steel stem, chrome plated brass or stainless steel full port ball, EPDM, PTFE or RTFE seats and seals, screwed ends (solder ends are acceptable only if rated for soldering in line with 470°F melting point of 95-5 solder).

2. Ball 3" to 6":

a. Design Pressure: 200 psi

1) Design Temperature: 212°F
2) Design Flow Differential Pressure Rating: 35 psi

b. Cast iron body, stainless steel stem, stainless steel full port ball, EPDM, PTFE or RTFE seats and seals, flanged ends.

3. Butterfly 2-1/2" to 12":

a. Design Pressure: 125 psi

1) Design Temperature: -20 to 212°F
2) Design Flow Differential Pressure Rating: 50 psi

b. Cast iron body, stainless steel stem with extended neck, aluminum-bronze or nickel-plated iron disc, EPDM seats and seals, fully lugged ends.

C. Modulating:

1. Globe 1/2" to 2":

a. Design Pressure: ANSI Class 250

1) Design Temperature: 280°F
2) Design Flow Differential Pressure Rating: 35 psi
3) Leakage: ANSI Class VI

b. Bronze or brass body, trim and plug; stainless steel stem; stainless steel or bronze seat; EPDM, PTFE or RTFE packing; threaded ends.

2. Globe 2-1/2" to 6":

a. Design Pressure: 125 psi

1) Design Temperature: 250°F
2) Design Flow Differential Pressure Rating: 25 psi
3) Leakage: ANSI Class III

b. Cast iron body, bronze or brass trim and plug; stainless steel stem; bronze seat; EPDM, PTFE or RTFE packing; flanged ends.

3. Ball 2" and under:

a. Design Pressure: 400 psi

1) Design Temperature: 250°F
2) Design Flow Differential Pressure Rating: 35 psi
3) Leakage: 0%

b. Bronze or brass body, nickel plated brass or stainless steel stem, chrome plated brass or stainless steel ball, EPDM, PTFE or RTFE seats and seals, PTFE characterizing disc, screwed ends.

4. Ball 2-1/2" to 6":

   a. Design Pressure: 200 psi

      1) Design Temperature: 212°F
      2) Design Flow Differential Pressure Rating: 35 psi
      3) Leakage: 0%

   b. Cast iron body GG25, stainless steel stem, stainless steel ball, EPDM, PTFE or RTFE seats and seals, stainless steel characterizing disc, flanged ends.

5. Butterfly 2-1/2” 12":

   a. Design Pressure: 125 psi

      1) Design Temperature: -20°F to 212°F
      2) Design Flow Differential Pressure Rating: 50 psi

   b. Cast iron body, stainless steel stem with extended neck, aluminum-bronze or nickel-plated iron disc, EPDM seats and seals, fully lugged ends.

6. Pressure Independent Control Valves (PIC Valves or PICV) 3/4" and Smaller:

   a. Design Pressure: 360 psi
   b. Close-off Pressure: 75 psig
   c. Design Temperature: Between 36°F to 212°F
   d. Pressure independent operation up to system delta-p of 50 psid minimum; maximum pressure drop of 5.0 psid at design flow; 0% leakage; forged brass body; NPT female ends; stainless steel ball and stem, PTFE seats and dual EPDM seals.
   e. To be used on all chilled water systems
   f. Acceptable Manufacturers:

      1) Flow Control Industries - Delta P Valves

7. Pressure Independent Control Valves (PIC Valves or PICV) NPS 6 (DN 150) and Smaller:

   a. Design Pressure for NPS 2 (DN 50) and Smaller: 360 psi
   b. Design Pressure for NPS 2-1/2 (DN 65) through NPS 6 (DN 150): ANSI 125, Class B
   c. Close-off Pressure for NPS 2 (DN 50) and Smaller: 200 psi
   d. Close-off Pressure for NPS 2-1/2 (DN 65) through NPS 6 (DN 150): 100 psi
   e. Design Temperature: Between 14°F to 250°F
   f. Pressure independent operation up to system delta-p of 50 psid minimum; maximum pressure drop of 5.0 psid at design flow.
   g. A characterized control valve shall be integrated with an ultrasonic flow meter providing analog flow feedback. The valve shall reposition to maintain the required flow with +/- 5% accuracy The flow meter shall incorporate an algorithm to automatically calculate the glycol concentration and be readable by a local device, BACnet or MODBUS.
   h. Leakage 0%; equal percentage flow characteristic.
   i. Body; NPS 2 (DN 50) and Smaller: Forged brass, nickel plated with NPT female ends; stainless steel ball and stem, PTFE seats, Teflon characterizing disc.
   j. Body; NPS 2-1/2 (DN 65) through NPS 6 (DN 150): Cast iron with pattern to mate with ANSI 125 flange, stainless steel ball and stem, PTFE seats, stainless steel characterizing disc.
   k. To be used on all chilled water systems
   l. Acceptable Manufacturers:

      1) Flow Control Industries - Delta P Valves

2.23 STEAM CONTROL VALVES

A. General:

1. Two-position valves shall have a maximum pressure drop equal to 10% of the inlet pressure.
2. Two modulating control valves in parallel shall have 1/3 - 2/3 capacities sequenced so that the smaller valve opens first.
3. The pressure drop through a modulating control valve with an inlet pressure less than or equal to 15 psig shall be equal to 80% of the inlet pressure. In no case shall the inlet pressure of the equipment after the valve be less than 2 psig, except for integral face and bypass coils where the inlet pressure after the valve shall not be less than 5 psig.
4. The pressure drop through modulating control valves with inlet pressures greater than 15 psig shall be equal to 42% of the inlet pressure but shall be required to provide outlet pressure of 1 psi above the scheduled or specified inlet pressure of the equipment served.
5. Piping geometry correction factors for C_v ratings shall be used and stated for ball valves, butterfly valves, or non-characterized valves.

B. Two-Position or Modulating (Low Pressure: 15 psi or below):

1. Globe 1/2” 2":

a. Design Pressure: ANSI Class 250

1) Design Temperature: 338°F
2) Design Flow Differential Pressure Rating: 35 psi
3) Leakage: ANI Class VI

b. Bronze or brass body, trim and plug; stainless steel stem; stainless steel plug and seat; EPDM, PTFE or RTFE packing; threaded ends.
c. Flow Characteristic: Equal percentage.

2. Globe 2-1/2” 6":

a. Design Pressure: 250 psi

1) Design Temperature: 337°F
2) Design Flow Differential Pressure Rating: 50 psi
3) Leakage: ANSI Class III

b. Bronze body, stainless steel trim, seat and plug; stainless steel stem; EPDM, PTFE or RTFE packing; threaded ends.
c. Flow Characteristic: Linear.

2.24 VALVE ACTUATORS

A. General:

1. Actuators shall be sized to operate the valve through its full range of motion and shall close against pump shutoff pressure without producing audible noise at any valve position.
2. Provide visual position indication.
3. Mount actuator directly on valve or provide linear motion assembly as required for valve type.

B. Valve Actuators - Electronic:

1. Actuator shall be UL 873 or 60730 listed and provided with NEMA housing for applicable environment, electronic overload protection to prevent actuator damage due to over-rotation. Mount actuator by means of a V-bolt dual nut clamp with a V-shaped toothed cradle, directly couple and mount to the valve bonnet stem, or ISO-style direct-coupled mounting pad. Actuators shall be capable of being mechanically and electrically paralleled to increase torque, if required.
2. Actuators shall be warranted for a period of five (5) years from the date of production, with the first two (2) years unconditional.
3. Proportional actuator position shall be proportional to analog or pulse width modulating signal from electronic control system.
4. Fail-Safe Valves: Where shown on the drawings or sequences, fail-safe mechanism shall operate the valve to the fail position following power interruption.

    a. Mechanical/Spring: Mechanical spring return mechanism to drive controlled drive to an end position (open or close) on loss of power.
    b. Electronic: Electronic fail-safe shall incorporate an active balancing circuit to maintain equal charging rates among the capacitors. The power fail position shall be proportionally adjustable between 0 to 100% in 10 percent increments with a 10 second operational delay.

5. Feedback: Where shown on drawings or sequences, provide analog feedback signal for positive position indication.

2.25 CONTROL INSTRUMENTATION

A. Temperature Measuring Devices:

1. Electric Thermostats:

    a. Single Temperature - Line Voltage Electric: Integral manual ON/OFF/AUTO selector switch, minimum dead band of 5°F, concealed temperature adjustment, locking cover, rated for load, single or double pole as required.
    b. Single Temperature - Low Voltage Electric: Integral manual ON/OFF/AUTO selector switch, minimum dead band of 5°F, anticipator circuits, concealed temperature adjustment, locking cover, 24 V control transformer (if not included with unit under control), single or double pole as required.

2. Low Limit Switch:

    a. Provide one foot of sensing element for each one square foot of coil area, maximum element length 25 feet, of the vapor tension type, so that any point along the entire length of measuring element can trigger the switch.
    b. Provide 3" minimum radius capillary support clips at each turn.
    c. Furnish each thermostat with one single pole, single throw normally-opened switch and one single pole, single throw normally-closed auxiliary switch.
    d. Setpoint range shall be 15°F to 55°F with a permanent stop at 35°F.
    e. Differential shall be fixed at approximately 5°F and supplied with manual reset.

B. Temperature Sensors:

1. Room Temperature Sensor:

    a. Sensor Only: Two-piece construction, ventilated plastic enclosure, off-white color, thermistor sensing element or resistance temperature device (RTD), 45°F to 90°F operating range, ± 0.50°F accuracy, no setpoint adjustment or override button.

b. Sensor with Setpoint Adjustment: Two-piece construction, ventilated plastic enclosure, off-white color, thermistor sensing element or resistance temperature device (RTD), 45°F to 90°F operating range, ± 0.50°F accuracy, with exposed single setpoint adjustment (no numeric temperature scale - provide with a single warmer/cooler or red/blue visual scale), no override button.

c. Sensor with Override: Two-piece construction, ventilated plastic enclosure, off-white color, thermistor sensing element or resistance temperature device (RTD), 45°F to 90°F operating range, ± 0.50°F accuracy, occupied/unoccupied override button with LED, no setpoint adjustment.

d. Sensor with Setpoint Adjustment and Override: Two-piece construction, ventilated plastic enclosure, off-white color, thermistor sensing element or resistance temperature device (RTD), 45°F to 90°F operating range, ± 0.50°F accuracy, with exposed single setpoint adjustment (no numeric temperature scale - provide with a warmer/cooler or red/blue visual scale), occupied/unoccupied override button with LED.

2. Duct Temperature Sensor:

a. Thermistor or RTD type. Pneumatic transmitters with transducers are not acceptable.

3. Water Temperature Sensor:

a. Install in immersion wells. Separate thermometers as specified elsewhere, also of the immersion well type, shall be installed within 2 feet of each temperature sensor.

C. Humidity Measuring Devices:

1. Humidity Sensors:

a. Humidity Sensors: Fully electronic with no moving parts or parts requiring periodic service. Accuracy shall be minimum of 2.0 %RH accuracy from 0-90 %RH and 2.5 %RH accuracy from 90-100 %RH humidity at temperatures from 50°F to 104°F.

2. Humidistats:

a. Room Humidistats: Wall-mounted, proportioning type, with adjustable 2% RH throttling range, operating range from 30% to 80% at temperatures up to 110°F, cover with concealed setpoint. Accuracy shall be minimum of 1.5 %RH accuracy from 0-90 %RH and 2.5 %RH accuracy from 90-100 %RH at temperatures from 50°F to 104°F.

b. Duct Humidistats: Proportioning insertion type, with adjustable 2% RH throttling range and operating range from 20% to 80% at temperatures up to 150°F. Accuracy shall be minimum of 1.5 %RH accuracy from 0-90 %RH and 2.5 %RH accuracy from 90-100 %RH at temperatures from 50°F to 104°F.

c. High Limit Duct Humidistat: 2-position insertion type, with differential maximum 2% RH.

D. Combination Room Temperature/Humidity Sensors:

1. Wall-mounted two-piece construction, plastic enclosure, off-white color with temperature and humidity measurement, exposed single setpoint adjustment and occupant override. Large display with temperature and %RH readout display, occupied/unoccupied override button with LED, and membrane keypad and gasketing for wipe-down cleaning.

2. Temperature Component: Thermistor sensing element or resistance temperature device (RTD), 45°F to 90°F operating range, ± 0.50°F accuracy.

3. Humidity Component: Proportioning type, with adjustable 2% RH throttling range, operating range from 0% to 90% at temperatures up to 110°F. Accuracy shall be minimum of 2.0 %RH accuracy from 0-90 %RH.

E. Enthalpy Sensors: Duct-mounted enthalpy sensor shall include solid state temperature and humidity sensors with electronics that shall output a 4-20 ma signal input to the controller upon a varying enthalpy (total heat) to enable economizer modes of operation when outside air enthalpy is suitable for free cooling.

F. Pressure Measuring Devices

1. Differential Pressure Switches:

a. Standard Pressure Switches:

1) Diaphragm-activated gauge with 4-3/4" dial, cast aluminum case, sealed interior, designed to resist shock and vibration, and rated for 15 psig.
2) Accuracy shall be ± 3% of full scale maximum throughout entire range at 70°F.
3) Provide mounting brackets, probes, and shutoff valves required for proper installation.
4) The range and service shall be as required for application or as noted on the drawings.
5) Provide two (2) photo-transistor-activated circuits and two (2) DPDT relays for both high or low limit alarms or controls.
6) Provide latching relays that require manual reset once activated.
7) Acceptable Manufacturer: Dwyer Photohelic Series 3000.

2. Pressure Transmitters/Transducer:

a. Air-to-Air:

1) Provide transducer having the following minimum performance for measuring duct static pressure for VFD control or measuring differential pressure across filter banks:

a) Accuracy: ±1.0% FS
b) Non-Linearity, BFSL: ±0.96% FS
c) Hysteresis: 0.10% full scale
d) Non-Repeatability: 0.05% full scale
e) Thermal Effects (compensated range): 0°F to +150°F
f) Maximum Line Pressure: 10 PSI
g) Zero/Span Shift: 0.033%FS/°F
h) Long Term Stability: 0.5%FS/1year

2) Provide transducer with the following minimum performance for measuring differential pressure across piezometer fan inlet airflow measuring stations:

a) Unit shall come factory equipped with static tube attached.
b) Unit shall include: (1) LCD shall display differential pressure on face of sensor enclosure over the entire operational range, and (2) IPCC-rated polycarbonate enclosure with short circuit proof outputs and reverse polarity protected inputs.
c) Accuracy at 72°F: ±0.25% FS
d) Stability: ±0.25% full scale per year
e) Temperature Error: (1) Zero: ±0.025% full scale per °C, (2) Span: Maximum ±0.03% full scale per °C
f) Environmental Operating Range: 32°F to 140°F.
g) Overpressure: Proof: (1) 2 psi, (2) Burst: 3 psi
h) Humidity: 0% to 95% RH non-condensing.

b. Wet-to-Wet (uses include measuring hydronic system differential pressure for VFD control):

1) Unidirectional pressure range selected for appropriate range based on the application.
2) Provide transducer with minimum 250 psi high side proof pressure and minimum 60 psi low side proof pressure.

3) Case shall be constructed of stainless steel/aluminum and shall be equipped with 1/4" threaded connections. Wetted parts shall be constructed of 300 series stainless steel. Provide transducer with Viton and silicone O-rings for solutions containing water and/or glycol. Provide transducer with Buna-N O-rings for hydrocarbon solutions.
4) Provide transducer with factory assembled 3-valve manifold assembly to allow for field calibration of transducer.
5) Performance shall be as follows:

a) Accuracy: ±0.25% F.S.
b) Non-Linearity: ±0.20% F.S.
c) Hysteresis: 0.10%F.S.
d) Non-Repeatability: 0.05% F.S.
e) Compensated Temp Range: +30°F to +150°F
f) Long Term Stability: 0.5% F.S./year

c. Saturated Steam:

1) 316 stainless steel pressure transmitters suitable for use with saturated steam and with minimum 200% proof pressure and 800% burst pressure. Provide with 17-4 PH stainless steel wetted parts (diaphragm).
2) Performance shall be as follows:

a) Pressure Range: 0-150 psig
b) Accuracy: ±1.0% F.S.
c) Thermal Effect: ±0.04% F.S./°F zero and span
d) Compensated Temp Range: -20°F to 160°F
e) Operating Temp Range: -40°F to 200°F
f) Long Term Stability: 0.5% F.S./Year

3) Provide with pigtail syphon and stainless-steel pressure snubber.
4) Manufacturer:

a) Kele PTX1
b) or approved equivalent

3. Room Pressure Monitor System:

a. General:

1) The room pressure monitor system shall include a room pressure monitor, remote pressure sensor, door switch, keyed switch, and low voltage control transformer.
2) The system shall continuously measure, display, and monitor the room pressure.
3) All components of the room pressure monitor system shall be completely designed, tested, cataloged, and coordinated for single point responsibility.
4) TCC shall furnish and install all wiring as required to connect system components.

b. Room Pressure Monitor:

1) Shall measure and display room pressure and provide access to menu driven programming options via a keypad. Refer to drawings for room pressure monitor requirements.
2) A minimum of two indicator lights shall be provided on the front of the monitor to indicate ALARM and NORMAL conditions.
3) There shall be an alphanumeric digital display indicating the measured room pressure in inches of H_2O with a display accuracy of 0.001 and shall be updated every second.
4) There shall be low and high pressure audible alarms. Each alarm shall have a unique setpoint.

5) The room pressure monitor shall not be capable of changing the room mode without the use of a password or keyed switch.
6) The room pressure monitor shall accept an input from the door switch to silence the alarm.
7) The room pressure monitor shall accept an input from the FMCS system to change the room mode as indicated in the control sequences.
8) Provide the following inputs/outputs to the FMCS system:

a) Pressure (analog).
b) Room Mode (binary).
c) Alarm (binary).

c. Pressure Sensor:

1) Shall be temperature compensated over a range of 55°F to 95°F.
2) The assembly shall not compromise the fire rating of the wall.
3) Shall measure room pressure from -0.20000 to +0.20000 inches H2O with an accuracy of ± 0.001 inches H2O.
4) Shall be bidirectional to determine the proper direction of pressure. Unidirectional sensors are not acceptable.
5) Manufacturer shall provide cable between the pressure sensor and room pressure monitor.

d. Door Switch:

1) Magnetic door switch designed to interface with room pressure monitor.

e. Transformer:

1) The transformer shall have a primary-side voltage of 120 VAC and a secondary-side voltage of 24 VAC.
2) The transformer shall be UL and CSA listed.
3) Manufacturer shall provide cable between the transformer and room pressure monitor.

f. Keyed Switch:

1) Two-position rotating cam-type with key removable in both positions. Rated for 20A at 120V UL listed. Back and side wired. Provide key and stainless steel coverplate in a single gang electrical rough-in box. Provide black laminated three-layer phenolic nameplate with engraved white, 1/4" minimum letters for labels.
2) Provide with spare keys.

4. Room Pressure Indicator:

a. General:

1) The room pressure monitor system shall include a room pressure monitor, pressure sensor, and low voltage control transformer.
2) The system shall continuously measure, display, and monitor the room pressure.
3) All components of the room pressure indicator shall be completely designed, tested, cataloged, and coordinated for single point responsibility.
4) Display shall be visual color indicator with pressure readout.
5) TCC shall furnish and install all wiring as required to connect system components.

b. Room Pressure Monitor:

1) Shall measure and display room pressure. Refer to drawings for room pressure monitor locations.

2) A minimum of two indicator colors shall be provided on the front of the monitor to indicate ALARM (red) and NORMAL (green) conditions.
3) There shall be an alphanumeric digital display indicating the measured room pressure in inches of H2O with a display accuracy of 0.001 and shall be updated every second.
4) Provide the following inputs/outputs to the FMCS system:

a) Pressure (analog).

c. Pressure Sensor:

1) Shall be temperature compensated over a range of 55°F to 95°F.
2) The assembly shall not compromise the fire rating of the wall.
3) Shall measure room pressure from -0.20000 to +0.20000 inches H2O with an accuracy of ± 0.001 inches H2O.
4) Shall be bidirectional to determine the proper direction of pressure. Unidirectional sensors are not acceptable.
5) Manufacturer shall provide cable between the pressure sensor and room pressure monitor.

d. Transformer:

1) The transformer shall have a primary-side voltage of 120 VAC and a secondary-side voltage of 24 VAC.
2) The transformer shall be UL and CSA listed.
3) Manufacturer shall provide cable between the transformer and room pressure monitor.

G. Flow Measuring Devices:

1. Flow Switches:

a. Suitable for the intended application (water or air system).
b. Vane Operated Flow Switch: Vane motion shall activate a single pole, double throw snap switch.

c. Insertion Type Turbine Flow Meters: General:

1) Each flow meter shall be an insertion type dual turbine flow meter.

d. Service:

1) Chilled Water: Rated for 32°F through 140°F service.
2) Condensate and Heating Water: Rated for minimum of 240°F service.

e. Turbine Flow Meter:

1) Each meter shall be rated for system pressure and shall have adequate structural integrity for a flow rate equal to 150% of the scheduled maximum initial or future flow rate, whichever is greater.
2) Each turbine flow meter shall be complete with all insertion hardware necessary to enable insertion and removal of the meter without system shutdown. The flow meter shall be hand insertable up to 400 PSI.
3) Each flow meter shall have contra-rotating axial turbines with electronic impedance based sensing (non-magnetic).
4) Dual turbine flow meters shall have an averaging circuit to reduce measurement error due to swirl and flow profile distortion.
5) Constructed of nickel plated brass with NEMA 4 powder coated cast aluminum enclosure.

6) Each meter shall be wet calibrated against a primary volumetric standard that is accurate to within 0.1% and traceable to NIST.

f. Output:

1) Each transmitter shall produce an analog output signal, 4-20 mA, 0-10 V, or 0-5 V that is directly proportional to volumetric flow rate.
2) The output shall be connected with display unitBTU meter.
3) All wire shall be carried into 1/2" NPTM conduit connection. The meter shall include 25 feet of cable to connect with a remotely mounted display unitBTU meter.
4) Unless scheduled or indicated otherwise, the initial span adjustment of each transmitter shall be 0-120% of the scheduled maximum flow rate.

g. Accuracy:

1) The accuracy of each meter/transmitter assembly shall be ± 1.0% of flow rate reading over a range of 3-15 feet/second fluid velocity, with a repeatability of 0.1%. Accuracy at 1 foot/second shall be ± 2.0%.

h. Display Unit:

1) Pair with Display Unit described below.

i. BTU Meter:

1) Pair with BTU Meter described below.

j. Calibration:

1) Each meter shall be calibrated on an NIST traceable flow stand at 1, 8, and 15 feet/second. Provide written documentation of calibration.
2) Billing Purposes: Each meter shall have factory fingerprinting to allow NIST traceable in-situ calibration verification to ± 1% of original factory calibration.

k. Installation Hardware:

1) The flow meter shall be supplied with standard installation hardware, which shall include, but not be limited to, full port bronze ball valve, brass close nipple, and weld-on carbon steel branch outlet.

l. Warranty:

1) Provide performance warranty of at least two years from the date of installation and startup. Warranty shall cover parts and labor for repair or replacement of the meter assembly. Performance during the warranty period shall satisfy the above-stated requirements for accuracy and repeatability.

m. Manufacturers:

1) Onicon

2. Insertion Type Turbine Condensate Flow Meters:
a. Turbine meter for up to 250°F and 150 psig.
b. Cast iron body with Ryton rotor and nose cone, stainless steel straightening valves, and EPDM seals.
c. Meter to read pounds (kilograms) of condensate.
d. Provide totalizer with contact pulse output to provide signal to DDC system every 1,000 pounds.

1) Onicon - C-Mag

3. Insertion Type Electromagnetic Flow Meter:

a. General:

1) Each flow meter shall be of the magnetic insertion type.

b. Service:

1) Chilled Water: Rated for 32°F through 140°F service.
2) Condensate and Heating Water: Rated for minimum of 240°F service.

c. Insertion Type Electromagnetic Flow Meter:

1) Each meter shall be rated for system pressure and shall have adequate structural integrity for a flow rate equal to 150% of the scheduled maximum initial or future flow rate, whichever is greater.
2) Each insertion type electromagnetic flow meter shall be complete with all hardware necessary to enable insertion and removal of the meter without system shutdown. The flow meter shall be hand insertable up to 400 PSI.
3) Construction:

a) Wetted Components: 316 stainless steel
b) Sensor Head: Polypropylene
c) Electronics enclosure shall be NEMA 4 and aluminum.

4) Each meter shall be wet calibrated against a primary volumetric standard that is accurate to within 0.1% and traceable to NIST.

d. Output:

1) Output signals shall be completely isolated and shall consist of the following:

a) Analog output; 4-20mA, 0-10V, or 0-5V jumper selectable.
b) Scalable dry contact output for totalization.

2) The output shall be connected with display unitBTU meter.
3) The meter shall include 25 feet of cable to connect with a remotely mounted display unitBTU meter.
4) Unless indicated otherwise, the initial span adjustment of each transmitter shall be 0-120% of the scheduled maximum flow rate.

e. Accuracy:

1) The accuracy of each meter/transmitter assembly shall be ± 1.0% of flow rate reading over a range of 3-15 feet/second fluid velocity, with a repeatability of 0.1%. Accuracy at 1 foot/second shall be ± 2.0%.

f. Display Unit:

1) Pair with Display Unit described below.

g. BTU Meter:

1) Pair with BTU Meter described below.

h. Calibration:

1) Each meter shall be calibrated on a NIST traceable flow stand at 1, 8, and 15 FPS. Provide written documentation of calibration.

i. Installation Hardware:

1) The flow meter shall be supplied with standard installation hardware, which shall include, but not be limited to, full port bronze ball valve, brass close nipple and weld-on carbon steel branch outlet.

j. Warranty:

1) Provide performance warranty of at least two years from the date of installation and startup. Warranty shall cover parts and labor for repair or replacement of the meter assembly. Performance during the warranty period shall satisfy the above-stated requirements for accuracy and repeatability.

k. Manufacturers:

1) ABB
2) Onicon
3) Magmeter.

4. Inline Electromagnetic Flow Meters:

a. General:

1) Each flow meter shall be of the electromagnetic type.

b. Service:

1) Chilled Water: Rated for 32°F through 140°F service.
2) Condensate and Heating Water: Rated for minimum of 240°F service.

c. Electromagnetic Flow Tube:

1) Each meter shall be rated for system pressure and shall have adequate structural integrity for a flow rate equal to 150% of the scheduled maximum initial or future flow rate, whichever is greater.
2) Each meter shall have flanged connections to match piping pressure class, an outer body constructed of 316 stainless steel, a full line-size 304 stainless steel flow tube, 316 stainless steel electrodes, and a liner that is fully compatible with the chemical content of the flow media.
3) Each meter shall be provided with an adequate means for grounding the process fluid (e.g., grounding rings or a grounding electrode).

d. Transmitter:
1) Each meter shall incorporate an integral programmable transmitter that incorporates a digital display.
2) Each transmitter shall calculate and display flow rate and net totalized flow, along with associated engineering units (e.g., GPM and Gal.).
3) Each transmitter shall produce an analog output signal that is directly proportional to volumetric flow rate. This signal shall be scalable to indicate flow rate in either direction. In lieu of such bidirectional scalability, two separate pulsed outputs shall be provided. One shall indicate incremental flow in one direction, while the other indicates incremental flow in the opposite direction such that net totalized flow can be calculated remotely.
4) Unless scheduled or otherwise indicated, the initial span adjustment of each transmitter shall be 0-120% of the scheduled maximum flow rate.

5) Each transmitter shall incorporate self-diagnostics and test functions to permit internal checks of all outputs and displays, and to verify the accuracy of the unit and the integrity of the current loop without any external equipment.

e. Accuracy:

1) Non-billing Purposes: The accuracy of each meter/transmitter assembly shall be ± 0.5% of flow rate reading over a range of 3-15 feet/second fluid velocity, with a repeatability of 0.1%. Accuracy at 1 foot/second shall be ± 0.75%.

f. Display Unit:

1) Pair with Display Unit described below.

g. BTU Meter:

1) Pair with BTU Meter described below.

h. Calibration:

1) Each meter shall be calibrated on an NIST traceable flow stand at 1, 8, and 15 feet/second. Provide written documentation of calibration.
2) Billing Purposes: Each meter shall have factory fingerprinting to allow NIST traceable in-situ calibration verification to ± 1% of original factory calibration.

i. Installation and Startup:

1) Each meter assembly shall include detailed installation and operation instructions, including piping straight run requirements.
2) Provide on-site startup, commissioning, and training.

j. Warranty:

1) Each meter assembly shall carry a performance warranty of at least two years from the date of installation and startup. This warranty shall cover parts and labor for repair or replacement of the meter assembly. Performance during the warranty period shall satisfy the above-stated requirements for accuracy and repeatability.

k. Manufacturers:

1) Onicon system 10

5. Display Unit:

a. General:

1) The display shall compatible with virtually any flow meter.
2) The display module shall provide a local indication of liquid flow rate and net totalized flow, along with associated engineering units (e.g., GPM/second and gallons).
3) It shall have a network interface to communicate flow data to the building control network.
4) House in a steel wall-mounted enclosure with a built-in user interface/display.
5) Display unit shall accept 4-20 mA pulse or contact closure flow signals. It shall also function as a network interface for two (2) additional analog rate inputs and one (1) additional totalizing pulse input.
6) It shall support BACnetLonWorks communication protocols.
7) The display shall have two-line alphanumeric LCD displays of flow rate and flow total.

8) The display shall have non-volatile EEPROM memory that retains all program parameters and totalized values in the event of power loss.
9) Electrical Power Supply: 24VAC. 60Hz, 500mA max.

b. Manufacturers:

1) Onicon
2) Yokogawa
3) Badger.

6. BTU Meter:

a. General:

1) Microprocessor based thermal energy meter with LCD display.
2) BTU meter shall work with all common types of flow meters, temperature sensors, and pressure sensors. It shall display total energy, total flow, energy rate, flow rate, supply temperature, and return temperature.
3) It shall be compatible with BACnetLonWorks network interface and shall input these values to the network area controller.
4) It shall be suitable for liquid temperature range of 25°F to 240°F and ambient temperature range: -20°F to 140°F.
5) BTU meter shall have LCD display as follows:

a) Alpha: 16 character, 0.2" high
b) Numeric: 6 digit, 0.4" high
c) Rate Display Range: 0-9,999,999
d) Total display Range: 0-9,999,999

6) The meter shall be compatible with liquid flow signal input of 0-15 V pulse output or 4-20 mA analog output from any flow meter.
7) The meter shall provide output signals as follows:

a) Isolated solid-state dry contacts for energy total, maximum contact rating: 100 mA, 50 V.
b) Multiple isolated analog or digital outputs for energy rate, flow rate, supply and return temperature and delta temperature. Output type: 4-20mA, 0-10 V, or 0-5 V.
c) Interval Data Logging: This option provides at least 24 hours of rate and total data logging in 15-minute intervals. Data includes date/time stamp, measured value, and scaling factors when appropriate.
d) Network interface: BACnetLonWorks.

8) Electrical Input Power: 120 VAC, 60 Hz.

b. Accuracy:

1) The accuracy of BTU meter shall be ± 0.5% of flow rate reading over a range, with a repeatability of 0.1%.

c. Warranty:

1) Each BTU meter assembly shall carry a performance warranty of at least two years from the date of installation and startup. This warranty shall cover parts and labor for repair or replacement of the meter assembly. Performance during the warranty period shall satisfy the above-stated requirements for accuracy and repeatability.

d. Manufacturers:

1) Onicon
2) Yokogawa
3) Badger.

7. Airflow Measuring Stations:

a. Duct Mounted Airflow Measuring Stations (AFMS) - Thermal Dispersion:

1) Provide airflow/temperature measurement devices where indicated on the plans.
2) Each AFMS shall consist of one or more sensor probes and a single, remotely mounted, microprocessor-based transmitter capable of independently processing up to 16 independently wired sensor assemblies.

a) Each sensor assembly shall contain two individually wired, hermetically sealed bead-in-glass thermistors.
b) Thermistors shall be mounted in the sensor assembly using a marine-grade, waterproof epoxy. Thermistor leads shall be protected and not exposed to the environment.
c) Devices using chip-in-glass or diode-case chip thermistors are not acceptable.
d) Devices using less than two thermistors in each sensor assembly are not acceptable.
e) Devices using platinum wire RTDs are not acceptable.
f) Devices having electronic circuitry mounted in or at the sensor probe are not acceptable.
g) Pitot tubes and arrays are not acceptable.
h) Vortex shedding devices are not acceptable.

3) All Sensor Probes:

a) Each sensor assembly shall independently determine the velocity and temperature at its measurement point.
b) Each sensor assembly shall be calibrated at a minimum of 16 airflow rates and 3 temperatures to standards that are traceable to the National Institute of Standards and Technology (NIST).
c) Airflow measuring station assembly accuracy shall be ± 2% of Reading over the entire operating airflow range. Temperature accuracy shall be ± 0.15° F between -20° F and 160° F.
d) The operating humidity range for each sensor probe shall be 0-99% RH (non-condensing).
e) Each sensor probe shall have an integral, UL listed, plenum rated cable and terminal plug for connection to the remotely mounted transmitter. A single manufacturer shall provide both the airflow/temperature measuring probe(s) and transmitter for each measurement location.
f) The number of probes shall be as recommended by the manufacturer to achieve the specified accuracy.

4) Duct and Plenum Probes:

a) Probes shall be constructed of extruded, gold anodized, 6063 aluminum tube. All wires within the aluminum tube shall be Kynar coated.
b) Probe assembly mounting brackets shall be constructed of 304 stainless steel.
c) The operating airflow range shall be 0 to 5,000 FPM unless otherwise indicated on the plans.

5) Sensor Density:

Area (sq.ft.)	Total # of Sensors Required
Less than 2	4
2 to less than 4	6
4 to less than 8	8
8 to less than 16	12
≥ 16	16

6) Transmitters:

a) The transmitter shall have an integral 16-character alphanumeric LCD display capable of simultaneously displaying individual airflow and temperature.
b) The transmitter shall be capable of field configuration and diagnostics using an on-board interface and LCD display.
c) The operating temperature range for the transmitter shall be -20° F to 120° F.
d) The transmitter shall be capable of communicating with other devices using one of the following interface options:
e) Option 1: Linear analog output signals for airflow and temperature: Field selectable, fuse protected and isolated, 0-10VDC/4-20mA (4-wire)
f) Option 2: RS-485: Field selectable BACnet-ARCNET, BACnet-MS/TP, Modbus-RTU or Johnson Controls N2-Bus. BACnet devices shall provide analog variables for airflow and temperature containing individual sensor airflow rate and temperature data.
g) Option 3: 10 Base-T Ethernet: Field selectable BACnet Ethernet, BACnet-IP, Modbus-TCP and TCP/IP. Provide dynamic link libraries and VBA functions to interface Ethernet devices to Microsoft Excel for remote monitoring of airflow and temperature using a Windows 2000 or Windows XP based PC.
h) Option 4: LonWorks Free Topology

H. Current Measuring Devices:

1. Current Switches for Constant Speed Motors:

a. Digital device rated for amperage load of motor or device with split core design, adjustable high and low trip points, 600 VAC rms isolation, induced power from the monitored load, LED indicator lamps for output status and sensor power. The device shall sense overloading, belt-loss, and power failure with a single signal.

2. Current Switches for Motors Controlled by VFD:

a. Digital device rated for amperage load of motor or device with split core design, factory programmed to detect motor undercurrent conditions on variable or constant volume loads, self-calibrating, positive status indication, LED indicator lamps, 600 VAC rms isolation, induced power from the monitored load with NO output. The current sensor shall store the motor current operating parameters in non-volatile memory and have a pushbutton reset to clear the memory if the operating parameters change or the sensor is moved to another load. The device shall sense overloading, belt-loss, and power failure with a single signal. The sensor shall be mounted on the load side of variable frequency drives.

I. Occupancy Sensors:

1. Use auxiliary contacts on sensor provided and installed by the Electrical Contractor. Refer to electrical drawings for sensor location and specifications. Coordinate with Electrical Contractor.
2. Ceiling mounted, dual technology: sonic and passive infrared, 360° coverage pattern, zero crossing circuitry, adjustable sensitivity and time delay (initial setting: Time delay - 5 minutes unless noted otherwise below, integral isolated relay with normally open and normally closed outputs, LED indicator, five-year warranty, UL listed. TCC shall submit manufacturer supplied sensor layout drawing for shop drawing review. Provide full room coverage as recommended by manufacturer.

3. Space Occupancy Initial Setting Schedule
4. Initial Time
5. Space Delay Setting
6. Classroom 10 minutes
7. Reception 20 minutes

J. Carbon Dioxide Sensors:

1. Microprocessor based non-dispersive infrared sensor with range of 0 to 2,000 ppm CO2 with ± 100 ppm accuracy, maximum drift (compensated) of ± 5% full scale in five years, VOC software and hardware sensing, duct mounting where applicable, 0-10V dc or 4-20 mA output directly proportional to ppm, adjustable alarm limit, membrane filter, and terminal block. The diffusion gas chamber in the sensor shall incorporate a reflective light pipe or wave guide surrounded by a gas permeable membrane that prevents particulate contamination of the sensor. Unit shall have selectable IAQ mode with output signal and sum of CO2 and VOC levels.

K. Miscellaneous Devices:

1. Application Specific Controller Power Supply:

a. For use with terminal air box and recessed heaters.
b. Provide multiple enclosures with the following accessories and components as required to provide 24VAC power to terminal air boxes, differential pressure monitors, damper actuators, valve actuators, and other components and devices as required.
c. NEMA-1 steel enclosures (12"x12"x6") with separate high and low voltage compartments and separate access covers.
d. Either one 300 VA power supply with three 100 VA Class 2 outputs, or one 500 VA power supply with five 100 VA Class 2 outputs.
e. Primary side shall receive 480/277/240/120 input to 24 VAC ungrounded, isolated output on the secondary side.
f. Each secondary output shall include a 4 amp breaker, on/off switch, and LED indicator. Terminal blocks shall accept 16-22 AWG wire.
g. Acceptable Manufacturer:

1) RIB Functional Devices Model MSH300A-LVC or PSH500A-LVC

2. Control Relays:

a. Form "C" contacts rated for the application with "push-to-test" contact transfer feature and an integral LED to indicate coil energization.
b. Mount all relays and power supplies in a NEMA 1 enclosure beside the FMCS panel or controlled device and clearly label their functions.

3. Thermostat and Sensor Enclosures:

a. Clear plastic guard with lock. Wire guard with tamperproof screws. Setpoint shall be adjustable with cover in place. Fasten to wall separately from thermostat. Provide guards in all corridors, gymnasiums, locker rooms, toilet rooms, assembly halls and as noted on the drawings.
b. Heavy Duty Enclosure:

1) Perforated steel, tamperproof locking thermostat and control device enclosure.
2) Box shall be nominally 8"x6"x2" deep or sized as required to fit devices to be enclosed.
3) Perforated cover shall be 16 gauge steel with maximum 3/16" perforations on maximum 1/4" staggered centers for a 55% free area.
4) Secure to wall from inside of box. Cover shall be secured by tamperproof screws to frame.
5) Color shall match electrical devices. Verify color with the Electrical Contractor.

4. Drain Pan Condensate Overflow Switch: Float with integral magnet overflow switch conforming to UL508. No standby power required.

L. Outdoor Weather Station:

1. Outdoor rated ventilated plastic enclosure, off-white color, radiation shield including the following parameters.
2. Measured Parameters:

a. Temperature Sensor: Thermistor sensing element or resistance temperature device (RTD).

1) Operating Range: -40°F to 140°F
2) Accuracy: ± 0.54°F at 68°F

b. Humidity Sensors: Fully electronic with no moving parts or parts requiring periodic service.

1) Measurement Range: 0-100% RH
2) Accuracy:

a) ± 3% of reading from 0%-90% RH at 50°F to 86°F
b) ± 5% of reading from 0%-90% RH at -4°F to 50°F and 86°F to 140°F.

3. Calculated Parameters:

a. Dew Point Temperature in °F
b. Wet Bulb Temperature in °F
c. Enthalpy. Enthalpy sensor shall output a 4-20 ma signal input to the controller upon a varying enthalpy (total heat) to enable economizer modes of operation when outside air enthalpy is suitable for free cooling.

2.26 CONDUIT AND BOXES

A. Conduit and Boxes: Refer to Electrical Section 26 05 33 for materials, sizing, and other requirements

B. Conduit and Box Identification (Color and Labeling):

1. Refer to the Temperature Control Contractor notes located on the temperature controls cover sheet for raceway and box color requirements.
2. Refer to Electrical Section 26 05 53 for raceway and box labeling requirements.

2.27 WIRE AND CABLE

A. Wire and Cable: Refer to Electrical Section 26 05 13 for wire and cable materials.

1. Wire and Cable Color: Refer to the Temperature Control Contractor notes located on the temperature controls cover sheet for wire and cable color requirements.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION

A. Verify that systems are ready to receive work. Beginning of installation means installer accepts existing conditions.

B. Install system and materials in accordance with manufacturer's instructions.

C. Drawings of the TCS and FMCS network are diagrammatic only. Any apparatus not shown but required to meet the intent of the project documents shall be furnished and installed without additional cost.

D. Install all operators, sensors, and control devices where accessible for service, adjustment, calibration, and repair. Do not install devices where blocked by piping or ductwork. Devices with manual reset or limit adjustments shall be installed below 6'-0" if practical to allow inspection without using a ladder.

E. Verify locations of wall-mounted devices (such as thermostats, temperature and humidity sensors, and other exposed sensors) with drawings and room details before installation. Coordinate mounting heights to be consistent with other wall-mounted devices. Maximum height above finished floor shall not exceed ADA mounting requirements.

F. Provide valves over 3/4" size with position indicators and pilot positioners where sequenced with other controls.

G. Mount control panels adjacent to associated equipment on vibration-free walls or freestanding angle iron supports. One cabinet may accommodate more than one system in same equipment room.

H. After completion of installation, test and adjust control equipment.

I. Check calibration of instruments. Recalibrate or replace.

J. Furnish and install conduit, wire, and cable per the National Electric Code, unless noted otherwise in this section.

K. All controls associated with the proper operation of air handling units, pumps, or other mechanical equipment served by emergency power shall be connected to the emergency power system. Control components shall be powered from the equipment branch. In no instance shall panel be connected to the life safety branch of the emergency power system. Panels may be connected to a common 20 amp, 120 volt circuit provided the total load on the circuit does not exceed 16 amps. Circuit conductors shall be sized per the table below. All power connections to the control panels shall be performed by a licensed electrician at the cost of this Contractor. Submit circuit information (total amperage on circuit, conductors length, and panel) for control panels to the Architect/Engineer for approval.

Circuit Load (Amps)	Circuit Max Length	Feeder Size
≤ 5	≤ 200ft	2#12 & 1#12 ground in 3/4" conduit.
≤ 10	≤ 100ft	2#12 & 1#12 ground in 3/4" conduit.
≤ 16	≤ 75ft	2#12 & 1#12 ground in 3/4" conduit.
≤ 200	≤ 325ft	2#10 & 1#10 ground in 3/4" conduit.
≤ 100	≤ 160ft	2#10 & 1#10 ground in 3/4" conduit.
≤ 75	≤ 100ft	2#10 & 1#10 ground in 3/4" conduit.

L. All hardware, software, equipment, accessories, wiring (power and sensor), piping, relays, sensors, power supplies, transformers, and instrumentation required for a complete and operational FMCS system, but not shown on the electrical drawings, are the responsibility of the TCC.

M. Remodeling:

1. All room devices as indicated on the drawings shall be removed by this Contractor. The Contractor shall also prepare the wall for finishes. Preparing the wall shall include patching old anchor holes (after the anchoring device has been removed) and sanding the wall to remove old paint outlines remaining from original devices. The wall shall be painted to match the existing wall prior to the installation of the new room device. If wall covering requires patching, the Contractor shall furnish new wall covering to match existing. If new wall covering is not available to match existing, the Contractor shall furnish a white acrylic or Plexiglas plate, 1/4" thick and sized to cover the void.

N. Labels For Control Devices:

1. Provide labels indicating service of all control devices in panels and other locations.
2. Labels may be made with permanent marking pen in the control panels if clearly legible.
3. Use engraved labels for items outside panel such as outside air thermostats.
4. Labels are not required for room thermostats, damper actuators and other items where their function is obvious.

O. VFDs:

1. This project includes several variable frequency drives to control the flow of fans and/or pumps based on a control variable.
2. Verify output signal required, 4-20 mA or 0-10V dc, with the EC.
3. If VFD has a bypass feature, auxiliary contacts on the drive may not be used for motor status. A separate relay must be used to indicate motor rotation in either hand or auto positions.
4. If a separate current transmitter or switch is indicated for status, install this device between the VFD and the motor. In this case, the drive status may be connected to the auxiliary contacts in the VFD.
5. Some devices, such as low limits and fire alarm shutdown relays, must be hardwired to the fan motor. Make connections such that fan will shut down whether in hand or auto position if the unit has a bypass feature.

P. Airflow Stations:

1. The transmitter shall be installed at a location that is protected from weather, water, and vibration.
2. Mount transmitter where they can easily be read (36" to 66" above floor). Do not fasten transmitters directly to ductwork or compromise duct insulation.
3. The manufacturer's authorized representative shall visit the project site during construction prior to station installations to confirm all submitted sizes, mounting requirements and locations. Size adjustments shall be made at no additional cost. The representative shall meet on site with the TCC to support and train them on proper installation procedures and calibration.
4. Install labels at each sensor and transmitter identifying its service.

3.2 GRAPHIC DISPLAY

A. Create a customized graphic for each piece of equipment indicated on the itemized points list.

B. Components shall be arranged on graphic as installed in the field.

C. Include each graphic point listed in the itemized points list using real time data.

D. Provide a graphic representation of the following:

1. Where there are multiple buildings, color code the campus map by the systems serving that building. The building graphic shall be linked to the graphic for that building's systems.
2. Where there are multiple floors, provide color codes/designations for the areas served by each AHU and TAB by floor.
3. Where multiple AHUs serve one floor, color code the areas served by each AHU. The area shall be linked to the graphic for that area's AHU.

4. Provide an overall floor plan of each floor of the building color coded by zone linked to the TAB for that zone. The zone shall be linked to the graphic for that zone's TAB graphic.
5. Show the location of each thermostat on the floor plan.
6. Provide separate graphics showing the chilled and heating water system flow diagram. Show temperatures and flows on the flow diagram. Each piece of equipment shown on the flow diagram shall be linked to the graphic for that piece of equipment.
7. Provide a graphic showing the steam system flow diagram. Show pressures and flows on the flow diagram. Each piece of equipment shown on the flow diagram shall be linked to the graphic for that piece of equipment.

E. The FMCS shall include full graphic operator interface to display the following graphics as a minimum:

1. Home page to include a minimum of six critical points: Outside Air Temperature, Outside Air Relative Humidity, Enthalpy, KWH, KW, etc.
2. Graphic floor plans accurately depicting rooms, walls, hallways, and showing accurate locations of space sensors and major mechanical equipment.
3. Detailed graphics for each mechanical system including AHUs, ERUs, EFs, chillers, and boilers, as a minimum.
4. Access corresponding system drawings, technical literature, and sequences of operations directly from each system graphic.

F. The FMCS shall include individual graphical buttons to access the following data stored in PDF format:

1. Project control as-built documentation including all TCS drawings, diagrams and sequences of operation.
2. TCS Bill of Material for each system, e.g. AHU, RTU, FCU, boiler, etc.
3. Technical literature specification data sheets for all components listed in the TCS Bill of Material.

3.3 CONDUIT AND BOXES INSTALLATION

A. Conduit and Box Installation: Refer to Electrical Section 26 05 33 for execution and installation.

B. Conduit and Box Identification (color and labeling) installation. Refer to Electrical Section 26 05 53 for raceway and box identification installation.

C. Outlet Box Schedule: Thermostat/temperature sensor:

1. Dry Interior Locations: Provide 4" square galvanized steel with raised cover to fit flush with finished wall line. When located in concrete block walls, provide square edge title cover of sufficient depth to extend out to face of block or masonry boxes.
2. Other Conditions: Refer to Electrical Section 26 05 33 for requirements.

3.4 WIRE AND CABLE INSTALLATION

A. Wire and Cable Installation: Refer to Electrical Section 26 05 13 for execution and installation.

B. Field Quality Control:

1. Inspect wire and cable for physical damage and proper connection.
2. Torque test conductor connections and terminations to manufacturer's recommended values.
3. Perform continuity test on all conductors.

4. Protection of cable from foreign materials:

   a. It is the Contractor's responsibility to provide adequate physical protection to prevent foreign material application or contact with any cable type. Foreign material is defined as any material that would negatively impact the validity of the manufacturer's performance warranty. This includes, but is not limited, to overspray of paint (accidental or otherwise), drywall compound, or any other surface chemical, liquid or compound that could come in contact with the cable, cable jacket or cable termination components.
   b. Overspray of paint on any cable, cable jacket or cable termination component will not be accepted. It shall be the Contractor's responsibility to replace any component containing overspray, in its entirety, at no additional cost to the project. Cleaning of the cables with harsh chemicals is not allowed. This requirement is regardless of the PASS/FAIL test results of the cable containing overspray. Should the manufacturer and warrantor of the structured cabling system desire to physically inspect the installed condition and certify the validity of the structured cabling system (via a signed and dated statement by an authorized representative of the structured cabling manufacturer), the Owner may, at their sole discretion, agree to accept said warranty in lieu of having the affected cables replaced. In the case of plenum cabling, in addition to the statement from the manufacturer, the Contractor shall also present to the Owner a letter from the local Authority Having Jurisdiction stating that they consider the plenum rating of the cable to be intact and acceptable.

3.5 FMCS INSTALLATION

A. Coordinate voltage and ampacity of all contacts, relays, and terminal connections of equipment being monitored or controlled. Voltage and ampacity shall be compatible with equipment voltage and be rated for full ampacity of wiring or overcurrent protection of circuit controlled.

B. Naming Conventions: Coordinate all point naming conventions with Owner standards. In the absence of Owner standards, naming conventions shall use equipment designations shown on plans.

3.6 COMMISSIONING

A. Upon completion of the installation, this Contractor shall load all system software and start up the system. This Contractor shall perform all necessary calibration, testing and de-bugging and perform all required operational checks to ensure that the system is functioning in full accordance with these specifications.

B. This Contractor shall perform tests to verify proper performance of components, routines, and points. Repeat tests until proper performance results. This testing shall include a point-by-point log to validate 100% of the input and output points of the FMCS system operation.

C. This Contractor shall prove that the controls network is functioning correctly and within acceptable bandwidth criteria and shall test the system with an approved protocol analysis tool. Provide a log and statistics summary showing that each channel is within acceptable parameters. Each channel shall be shown to have at least 25% spare capacity for future expansion.

D. Upon completion of the performance tests described above, repeat these tests, point by point, as described in the validation log above in the presence of Owner's Representative, as required. Properly schedule these tests so testing is complete at a time directed by the Owner's Representative. Do not delay tests so as to prevent delay of occupancy permits or building occupancy.

E. System Acceptance: Satisfactory completion is when this Contractor has performed successfully all the required testing to show performance compliance with the requirements of the Contract Documents to the satisfaction of the Owner's Representative. System acceptance shall be contingent upon completion and review of all corrected deficiencies.

3.7 PREPARATION FOR BALANCING

A. Verify that all dampers are in the position indicated by the controller (e.g., open, closed or modulating).

B. Check the calibration and setpoints of all controllers.

C. Check the locations of all thermostats and humidistats for potential erratic operation from outside influences such as sunlight, drafts, or cold walls.

D. Check that all sequences operate as specified. Verify that no simultaneous heating and cooling occurs, unless specified. Observe that heating cannot begin at TAB reheat terminals until the unit is at the minimum cfm.

E. Verify the operation of all interlock systems.

3.8 TEST AND BALANCE COORDINATION

A. The Contractor shall furnish a single set of all tools necessary to interface to the control system for test and balance purposes.

B. The Contractor shall provide a minimum of four (4) hours training for the Balancing Contractor in the use of these tools.

C. In addition, the Contractor shall provide a qualified technician to assist in the test and balance process until the first 20 terminal units are balanced.

D. The tools used during the test and balance process shall be returned at the completion of the testing and balancing.

3.9 DEMONSTRATION AND ACCEPTANCE

A. At completion of installation, provide two days minimum instruction for operators. Demonstrate operation of all controls and systems. Describe the normal operation of all equipment.

3.10 TRAINING

A. On-Site:

1. After completion of commissioning, the manufacturer shall provide 16 hours of training on consecutive days for 4 Owner's representatives. The training course shall enable the Owner's representatives to perform Day-to-Day Operations as defined herein. A factory-trained instructor with experience in presenting the training material and the system programmer for this project shall perform the training.

B. Day-to-Day Operations - Training Description:

1. Proficiently operate the system.
2. Understand control system architecture and configuration.
3. Understand FMCS systems components.
4. Understand system operation, including FMCS system control and optimizing routines (algorithms).
5. Operate the workstation and peripherals.
6. Log-on and off the system.
7. Access graphics, point reports, and logs.
8. Adjust and change system setpoints, time schedules, and holiday schedules.
9. Recognize malfunctions of the system by observation of the printed copy and graphic visual signals.

10. Understand system drawings and Operation and Maintenance manual.
11. Understand the job layout and location of control components.
12. Access data from FMCS controllers and ASCs.
13. Operate portable operator's terminals.

C. Advanced Operations - Training Description:

1. Make and change graphics on the workstation.
2. Create, delete, and modify alarms, including annunciation and routing of these.
3. Create, delete and modify point trend logs and graph or print these both on and ad-hoc basis and at user-definable time intervals.
4. Create, delete, and modify reports.
5. Add, remove, and modify system's physical points.
6. Create, modify and delete programming.
7. Add panels when required.
8. Add operator interface stations.
9. Create, delete, and modify system displays, both graphic and others.
10. Perform FMCS system field checkout procedures.
11. Perform FMCS controller unit operation and maintenance procedures.
12. Perform workstation and peripheral operation and maintenance procedures.
13. Perform FMCS system diagnostic procedures.
14. Configure hardware including PC boards, switches, communication, and I/O points.
15. Maintain, calibrate, troubleshoot, diagnose, and repair hardware.
16. Adjust, calibrate, and replace system components.

D. System Management - Training Description:

1. Maintain software and prepare backups.
2. Interface with job-specific, third-party operator software.
3. Add new users and understand password security procedures.

E. Provide course outline and materials in accordance with the "SUBMITTALS" article in Part 1 of this section. The instructor(s) shall provide one copy of training material per student.

3.11 INSTALLATION OF SENSORS

A. Install sensors in accordance with the manufacturer's recommendations.

B. Mount sensors rigidly and adequately for the environment within which the sensor operates.

C. Room temperature sensors shall be installed on concealed junction boxes properly supported by the wall framing.

D. All wires attached to sensors shall be air sealed in their raceways or in the wall to stop air transmitted from other areas affecting sensor readings.

E. Averaging sensors and low limits shall be installed at the top of the assembly with the element on a slight downward incline away from the sensor making a serpentine pattern over the cross-sectional area with elements spaced not over 12" apart and within 6" of the top and bottom of the area.

F. All pipe-mounted temperature sensors shall be installed in immersion wells. Install all liquid temperature sensors with heat-conducting fluid in thermal wells.

G. Install outdoor air temperature sensors on exterior of north wall, complete with sun shield at designated location approved by Architect/Engineer. TCC shall prime and paint the device enclosure. Color selection by Architect.

H. Install all wall-mounted CO_2 sensors between 3 feet and 6 feet above the floor.

3.12 INSTALLATION OF FLOW METERS

A. Provide manufacturer's recommended lengths of straight piping upstream and downstream of the flow meter. Up to 30 diameters upstream of the flow meter may be required depending on the piping arrangement and flow meter type.

B. Maintain adequate pull/service space.

END OF SECTION 23 09 00

SECTION 23 09 13 - INSTRUMENTATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Positive Displacement Meters.

B. Pressure Gauge.

C. Pressure Gauge Accessories.

D. Thermometers.

E. Test Plugs.

F. Static and Differential Airflow Pressure Gauges.

1.2 SUBMITTALS

A. Submit shop drawings per Section 23 05 00. Include list that indicates use, operating range, total range and location for manufactured components.

PART 2 - PRODUCTS

2.1 PRESSURE GAUGES

A. Gauges shall be 4-1/2" diameter with aluminum or stainless steel case with phosphor bronze bourdon tube, brass socket for air, steam, water or oil application, 1/4" or 1/2" bottom connection. Gauges shall be 1% full scale accurate with bronze bushed brass movement and adjustable pointer. Standard ranges to be either pressure or pressure and vacuum as required of application.

B. Manufacturers:

1. Ashcroft
2. Marsh
3. Marshalltown
4. Miljoco
5. Trerice
6. U.S. Gauge Figure 1901
7. Weiss
8. Weksler
9. Wika.

C. Select gauge range for normal reading near center of gauge.

2.2 PRESSURE GAUGE ACCESSORIES

A. All pressure gauges shall have valves and pressure snubbers. All pressure gauges on steam shall have pigtail syphon.

B. Shutoff Valve: 1/4" ball valve as specified for each piping system.

C. Pressure snubber, brass with 1/4" connections, porous metal type.

2.3 THERMOMETERS

A. Dial Type:

1. 4-1/2” diameter, hermetically sealed case. Stainless steel case and stem. Accuracy of 1% full scale with external recalibrator.
2. Select thermometers for appropriate temperature range. Adjustable elbow joint with locking device to allow rotation of thermometer to any angle.
3. Stem lengths as required for application with minimum insertion of 2-1/2”.
4. Thermometers for water, steam, or oil shall have brass or steel separable socket. Thermometer wells shall be stainless steel, pressure rated to match piping system design pressure; with 2 inch extension for insulated piping and threaded cap nut with chain permanently fastened to well and cap. Thermometers for air shall have an aluminum or brass duct flange.
5. Manufacturer:

   a. Ashcroft
   b. Marsh
   c. Marshalltown
   d. Miljoco
   e. Tel-Tru
   f. Trerice
   g. U.S. Gauge
   h. Weiss
   i. Weksler, Wika.

B. Alcohol/Spirit Filled Type:

1. 9” long phenolic case, steel stem, accuracy of 1% full scale. Adjustable elbow joint with 180 degree adjustment in vertical plane, 360 degree adjustment in horizontal plane, and locking device to allow rotation of thermometer to any angle.
2. Select thermometer for appropriate temperature range.
3. Stem: Copper plated steel, aluminum, or brass for separable socket. Stem lengths as required for application with minimum insertion of 3”.
4. Thermometers for water, steam, or oil shall have brass or steel separable socket. Thermometer wells shall be stainless steel, pressure rated to match piping system design pressure; with 2 inch extension for insulated piping and threaded cap nut with chain permanently fastened to well and cap. Thermometers for air shall have an aluminum or brass duct flange.
5. Manufacturer:

   a. Marsh
   b. Miljoco
   c. Trerice
   d. Weiss
   e. Weksler
   f. Wika.

C. Digital Type:

1. 1/2” LCD digital display, solar powered, with high impact ABS case. Accuracy of 1% of reading or 1°F, whichever is greater. Adjustable elbow joint with locking device to allow rotation of thermometer to any angle.
2. Fahrenheit/Celsius switchable with -50/300°F or range.
3. Through-case potentiometer recalibration adjustment.
4. Stem lengths as required for application, with minimum insertion of 2-1/2”.

5. Thermometers for water, steam, or oil shall have brass or steel separable socket. Thermometer wells shall be stainless steel, pressure rated to match piping system design pressure; with 2 inch extension for insulated piping and threaded cap nut with chain permanently fastened to well and cap. Thermometers for air shall have an aluminum or brass duct flange.
6. Digital display shall operate at 10 Lux (one foot-candle) or more. Use this thermometer only where ambient temperatures are below 140°F and there is sufficient light under normal occupied space conditions for the digital display to function. Use a different type thermometer where there is inadequate light available (i.e., dark mechanical rooms, locations where the thermometer is shielded from light, etc.).
7. Manufacturer:
    a. Miljoco
    b. Trerice
    c. Weiss
    d. Weksler
    e. Wika.

D. Dial Type with Remote Reading Dial:

1. 4-1/2” diameter remote mounted, vapor actuated dial, hermetically sealed case. Stainless steel case and stem. Accuracy of 1% full scale with external recalibrator.
2. Select thermometers for appropriate temperature range.
3. 0.13” diameter copper averaging bulb approximately 60" long. Install dial as shown on drawings and in location visible from floor. Insulate copper averaging bulb if required by manufacturer.
4. Stem lengths as required for application with minimum insertion of 2-1/2”.
5. Thermometers for water, steam, or oil shall have brass or steel separable socket. Thermometer wells shall be stainless steel, pressure rated to match piping system design pressure; with 2 inch extension for insulated piping and threaded cap nut with chain permanently fastened to well and cap. Thermometers for air shall have an aluminum or brass duct flange.
6. Manufacturer:
    a. Ashcroft
    b. Marsh
    c. Marshalltown
    d. Miljoco
    e. Tel-Tru
    f. Trerice
    g. U.S. Gauge
    h. Weiss
    i. Weksler
    j. Wika.

E. Select scales to cover expected range of temperatures.

2.4 STATIC AND DIFFERENTIAL AIRFLOW PRESSURE GAUGES

A. Diaphragm-activated gauge with 4-3/4” dial, cast aluminum case, sealed interior, designed to resist shock and vibration, and rated for 15 psig .

B. Accuracy shall be ± 3% of full scale maximum throughout entire range at 70°F.

C. Provide mounting brackets, probes, and shutoff valves required for proper installation.

D. The range and service shall be as required for application or as noted on the drawings.

E. Manufacturers:

1. Dwyer Magnehelic Series 2000
2. Marshalltown Instrument Series 85C.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General Installation Requirements:

1. Install per manufacturer's instructions.
2. Coil and conceal excess capillary on remote element instruments.
3. Install gauges and thermometers in locations where they are easily read from normal operating level.
4. Do not install instrumentation when areas are under construction, except for required rough-in, taps, supports and test plugs.

B. Positive Displacement Meters:

1. Install positive displacement meters with shutoff valves on inlet and outlet. Provide full line size valved bypass with globe valve for liquid service meters.

C. Pressure Gauges:

1. Connect pressure gauges to suction and discharge side of all pumps.
2. Provide snubber for each pressure gauge.
3. Provide coil syphon for each pressure gauge connected to steam piping.

D. Thermometers:

1. Install thermometers in piping systems in sockets in short couplings. Enlarge pipes smaller than 2-1/2” for installation of thermometer sockets.
2. Install thermometer sockets adjacent to control system thermostat, transmitter and sensor sockets.
3. Locate duct thermometers minimum 10 feet downstream of mixing dampers, coils, or other devices causing air turbulence.

END OF SECTION 23 09 13

SECTION 23 09 20 - VENTURI VALVE AIRFLOW CONTROL SYSTEM

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Venturi Airflow Control Valve

B. Controllers, Components

C. Interface to FMCS

1.2 QUALITY ASSURANCE

A. Manufacturer: Company specializing in manufacturing the products specified in this section, with minimum five years' experience.

B. The airflow system provider shall be an entity that designs, develops, manufactures, and sells products and services to control the environment and airflow of critical spaces using a Quality Management System registered to ISO 9001:2008.

C. Open loop venturi air valves that use damper position to represent flow must be calibrated on NVLAP accredited air stations.

D. Closed loop venturi air valves that measure airflow and control to setpoint must be ± 5% accurate over a 10:1 turndown. Third-party testing must be provided upon request.

1.3 REFERENCES

A. Air Conditioning and Refrigeration Institute

1. ARI 880 - Performance Rating of Air Terminals

B. American Society of Heating, Refrigeration, and Air Conditioning Engineers / American National Standards Institute

1. ASHRAE/ANSI Standard 130, Methods for Testing Air Terminal Units

C. American National Standards Institute / American Society of Heating, Refrigeration, and Air Conditioning Engineers

1. ANSI/ASHRAE 135-2012: BACnet® - A Data Communication Protocol for Building Automation Systems (including Standard and all published Addenda)

1.4 SUBMITTALS

A. Submit shop drawings per Sections 23 05 00 and 23 09 00. In addition, submit an electronic copy of the shop drawings in .pdf format to the Owner for review.

B. Refer to Section 23 09 00 for additional information.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Storage and Handling Requirements:

1. Prior to installation, the control system components shall be stored in dry conditions within an environment complying with the product specifications as shown on product data sheets within the submittals.
2. The system products shall be handled and transported in a manner consistent with trade practices for control systems and instruments.

1.6 JOB CONDITIONS

A. Cooperation with Other Trades: Coordinate the work of this section with that of other sections to ensure that the work will be carried out in an orderly fashion. It is this Contractor's responsibility to check the contract documents for possible conflicts between the work of this section and that of other crafts in equipment location; pipe, duct and conduit runs; electrical outlets and fixtures; air diffusers; and structural and architectural features.

1.7 WARRANTY

A. Warranty shall commence upon the date of shipment and extend for a period of 60 months for all airflow control devices and 36 months for all other control system components.

B. Refer to Section 23 05 00 for warranty requirements.

C. Within the warranty period, any defects in the work provided under this section due to faulty materials, methods of installation, or workmanship shall be promptly (within 48 hours after receipt of notice) repaired or replaced by this Contractor at no expense to the Owner.

D. Warranty requirements include furnishing and installing all FMCS software upgrades issued by the manufacturer during the one-year warranty period.

E. Update all software and backups during the warranty period and all user documentation on the Owner's archived software disks.

1.8 Pre-Installation Meetings

A. The critical environment control system representative shall review the proper installation of the system with the Sheet Metal Contractor and the BAS Contractor.

B. Project Installation Phase: The representative shall make periodic visits to the project job site to ensure that the system is being installed properly to assure optimal performance and that the location and orientation of the control valves is consistent for proper operation and future Owner maintenance. Any discrepancies shall first be brought to the attention of the appropriate subcontractor. If no action is taken by said subcontractor, the representative shall bring these issues to the Project Manager, Architect/Engineer, or Owner's Representative for resolution.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Phoenix Controls

B. Johnson Controls Critical Environments

2.2 AIRFLOW CONTROL SYSTEMS

A. A critical environment control system shall be furnished and installed to control the airflow into and out of laboratories and/or other areas as noted on the plans. The exhaust flow rate of a fume hood shall be controlled precisely to maintain a constant average face velocity into the fume hood at either a standard/in-use or standby level based on an operator's presence in front of the fume hood. The control system shall vary the amount of makeup/supply air into the room to operate the room at the lowest possible airflow rates necessary to maintain temperature control, achieve minimum ventilation rates, and maintain pressurization in relation to adjacent spaces (positive or negative). The critical environment control system shall be capable of operating as a standalone system or as a system integrated with the Facility Management and Control System (FMCS). An optional locally mounted user interface terminal shall be available to allow room-level control variables to be displayed, and where appropriate, edited to adjust control operation.

2.3 COMPONENTS

A. Usage Based Control Equipment:

1. For variable air volume (VAV) systems, a sash sensor shall be provided to measure the height of each vertically moving fume hood sash. A sash sensor shall also be provided to measure the opening of horizontal overlapping sashes. Control systems employing sidewall-mounted or through-the-wall (TTW) velocity sensors to control the fume hood exhaust airflow shall utilize dual air path with chip thermistor technology that can be demonstrated to meet sash response that meets ANSI Z95 performance guidelines. Hot wire anemometer sidewall sensors, or sensors that do not meet speed of response, are not acceptable.
2. The airflow at the fume hood shall vary in a linear manner between two adjustable minimum and maximum flow setpoints to maintain a constant face velocity throughout this range. A minimum volume flow shall be set to ensure flow through the fume hood even with the sash fully closed.

B. Airflow Control Device/ Venturi Valve - General:

1. The valve assembly manufacturer's airflow control device shall be registered to ISO 9001.
2. An open loop airflow control device shall be mechanically pressure independent over its specified differential static pressure operating range. An integral pressure independent assembly shall respond and maintain specific airflow within one second of a change in duct static pressure irrespective of the magnitude of pressure and/or flow change (within product specifications) or quantity of airflow controllers on a manifolded system.
3. A closed loop airflow control device shall measure airflow and control to a setpoint. Closed loop air valve shall be ± 5% accurate over a 10:1 turndown.
4. The airflow control device shall maintain accuracy within ± 5% of signal to setpoint.
5. No minimum entrance or exit duct diameters shall be required to ensure accuracy and/or pressure independence.
6. No rotational/axial orientation requirements shall be required to ensure accuracy and/or pressure independence.
7. The airflow control device shall maintain pressure independence regardless of loss of power. "Electronically pressure independent" devices are not acceptable.
8. Valve manufacturer will provide minimum required differential pressure in writing for each size valve they offer.
9. Devices that require duct static pressure to be increased to achieve maximum flow shall not be acceptable.

10. The airflow control device shall be constructed of:

    a. The airflow control device for non-corrosive airstreams, such as supply and general exhaust, shall be constructed of minimum 16 gauge aluminum. The device's shaft and internal "S" link shall be made of 316 stainless steel. The shaft support brackets shall be made of galvanneal (non-shutoff valves) or 316 stainless steel (shutoff valves). The pivot arm shall be made of aluminum (for non-shutoff valves) and 303/304 stainless (for shutoff valves). The pressure independent springs shall be a spring-grade stainless steel. All shaft bearing surfaces shall be made of a PP (polypropylene), PPS (polyphenylene sulfide) composite, or Teflon. Sound attenuating devices used in conjunction with general exhaust or supply airflow control devices shall be constructed using 24 gauge galvanized steel or other suitable material used in standard duct construction. No sound absorptive materials of any kind shall be used. Silencers shall be absorptive type with polymer-lined acoustic media.
    b. The airflow control device for corrosive airstreams, such as fume hoods and biosafety cabinets, shall have a baked-on, corrosion-resistant phenolic coating. The device's shaft shall be made of 316 stainless steel with a Teflon coating. The shaft support brackets shall be made of 316 stainless steel. The pivot arm and internal "S" link shall be made of 316 or 303 stainless steel. The pressure independent springs shall be a spring-grade stainless steel. The internal nuts, bolts, and rivets shall be stainless steel. All shaft bearing surfaces shall be made of PP (polypropylene), PPS (polyphenylene sulfide) composite, or Teflon.
    c. The airflow control device for highly corrosive airstreams shall be as described directly above. In addition, they shall have no exposed aluminum or stainless steel components. Shaft support brackets, pivot arm, and pressure independent springs shall have a baked-on, corrosion-resistant phenolic coating in addition to the materials defined directly above. The internal "S" link, nuts, bolts, and rivets shall be epoxy phenolic coated stainless steel. Only devices clearly defined as "high corrosion resistant" on project drawings will require this construction.
    d. The airflow control device for extremely corrosive airstreams, such as acid digestion fume hoods, shall have a PVDF (polyvinylidene fluoride fluoropolymer) coating. The device's shaft shall be made of 316 stainless steel with a Teflon coating. The shaft support brackets shall be made of 316 stainless steel with PVDF coating. The pivot arm and internal mounting link shall be made of 316 or 303 stainless steel with PVDF coating. The pressure independent springs shall be a spring-grade stainless steel with Teflon (PTFE) coating. The internal nuts, bolts, and rivets shall be stainless steel with PVDF coating. All shaft bearing surfaces shall be made of Teflon or PPS (polyphenylene sulfide) composite. Only devices clearly defined as "extremely corrosion resistant" on project drawings will require this construction.

        1) Note: Airflow control devices utilizing vortex shedding sensors and installed in fume hoods or corrosive environments MUST be constructed with stainless steel bodies and MUST have stainless steel vortex shedding sensors. Polycarbonate vortex shedding sensors are NOT acceptable in corrosive environments.

11. Actuation:
    a. For high speed electrically actuated VAV operation, a CE certified, UL listed, IP56 rated for dust and water, electronic actuator shall be factory mounted to the valve. Loss of main power shall cause the valve to position itself in an appropriate failsafe state. Options for these failsafe states include normally open-maximum position, normally closed-minimum position, and fail-to-last position. This position shall be maintained constantly without external influence, regardless of external conditions on the valve (within product specifications). During normal operation, the high speed actuated airflow control device shall initiate valve movement and achieve the commanded airflow value with no more than 5% overshoot or undershoot within 1 second or less.
    b. For standard speed electrically actuated VAV operation, a CSA certified, UL recognized (IP54 rating and CE certification optional on single valves, standard on dual valves) electronic actuator shall be factory mounted to the valve. The failsafe state for standard speed operation valves shall be fail to last position unless otherwise noted.
    c. During normal operation, the standard speed actuated airflow control device shall initiate valve movement and achieve the commanded airflow value with no more than 5% overshoot or undershoot within 60 seconds (90 seconds for a shutoff valve from shutoff to maximum flow or vice versa).

1) Standard speed actuation should not be used for valves that are connected to VAV fume hoods.
2) Standard speed actuation can be used on 2-state fume hoods or vented cabinets or snorkels with on/off conditions.

12. The room-level airflow control devices shall function as a standalone network.
13. There shall be no reliance on external or building-level control devices to perform room-level control functions. Each control system shall have the capability of performing fume hood control, pressurization control, standard and advanced temperature control, humidity control, and implement occupancy and emergency mode control schemes.
14. The critical environment control system shall have the option of digital integration with the FMCS.
15. NVLAP Accreditation (Lab Code 200992-0) (if applicable):

a. Each airflow control device shall be factory characterized on air stations NVLAP Accredited (a program administered by NIST) to ISO/IEC 17025:2005 standards.
b. Each airflow control device shall be factory characterized to the job specific airflows as detailed on the plans and specifications using NVLAP Accredited air stations and instrumentation having a combined accuracy of no more than ± 1% of signal (5,000 to 250cfm), ± 2% of signal (249 to 100cfm) and ± 3% of signal (199 to 35cfm). Electronic airflow control devices shall be further characterized and their accuracy verified to ± 5% of signal at a minimum of 48 different airflows across the full operating range of the device.
c. Each airflow control device shall be marked with device-specific factory characterization data. At a minimum, it should include the room number, tag number, serial number, model number, eight-point characterization information (for electronic devices), date of manufacture, and quality control inspection numbers. All information shall be stored by the manufacturer for use with as-built documentation. Characterization data shall be stored indefinitely by the manufacturer and backed up off site for catastrophic event recovery.

C. Exhaust and Supply Airflow Device Controller:

1. The airflow control device shall be a microprocessor-based design and shall use closed loop control to linearly regulate airflow based on a digital control signal. The device shall generate a digital feedback signal that represents its airflow.
2. During normal operation, the airflow control device shall initiate valve movement and achieve the commanded airflow value with no more than 5% overshoot or undershoot within:

a. 1 second or less with high speed actuation.
b. 60 seconds for standard speed actuation (90 seconds from shutoff to max flow and vice versa).

3. The airflow control device shall store its control algorithms in non-volatile, rewriteable memory. The device shall be able to be standalone or to be networked with other room-level digital airflow control devices using an industry standard protocol.
4. Room-level control functions shall be embedded in and carried out by the airflow device controller using distributed control architecture. Critical control functions shall be implemented locally; no separate room-level controller shall be required.
5. The airflow control device shall use industry standard 24 VAC power.
6. The airflow control device shall have provisions to connect a commissioning tool, and every node on the network shall be accessible from any point in the system.
7. The airflow control device shall have built-in integral input/output connections that address fume hood control, temperature control, humidity control occupancy control, emergency control, and non-network sensors switches and control devices. At a minimum, the airflow controller shall have:

a. Three universal inputs capable of accepting 0 to 10 VAC, 4 to 20 mA, 0 to 65 K ohms, or Type 2 or Type 3 10 K ohm @ 25°C thermistor temperature sensors.
b. One digital input capable of accepting a dry contact or logic level signal input.
c. Two analog outputs capable of developing either a 0 to 10 VAC @ 1 mA (10Kohm min) or 4 to 20 mA (500 ohm max) linear control signal.
d. One Form C (SPDT) relay output capable of driving up to 1 A @ 24 VAC/VAC.

8. The airflow control device shall meet FCC Part 15 Subpart J Class A, CE, and CSA Listed per file #228219.
9. The airflow control device shall be ROHS compliant.

D. Airflow Control Device/Venturi Valve - Leakage:

1. Two types of shutoff airflow devices shall be available: standard shutoff (no gasket) and low leakage shutoff (with gasket).
2. The shutoff airflow control device shall have shutoff leakage and casing leakage of no greater than the following (with 5.0" wc static pressure):

Shut-off Valve Type and Airflow Range	Shut-off Leakage	Casing Leakage
Standard shutoff devices up to 1600 CFM472 L/s	6 CFM	0.060 CFM
Low leakage shutoff devices up to 850 CFM	0.005 CFM	
Low leakage shutoff devices up to 1,300 CFM	0.010 CFM	

3. Manufacturer shall provide comprehensive leakage charts generated from ASME N510 pressure decay testing. Standard shutoff devices shall be tested up to and including 5" wc static pressure. Low-leakage shutoff devices shall be tested up to and including 30" wc static pressure.

E. Two-Position Exhaust Airflow Control Device/Venturi Valve:

1. The airflow control device shall provide functionality for constant volume, two position, or fully modulating. Two-position devices requiring feedback shall generate a 0 to 10 volt feedback signal that is linearly proportional to its airflow. All two-position devices shall be either networked or hard-wired into the room-level network to be considered under pressurization control.

F. Constant Volume Airflow Control Device:

1. The airflow control device shall maintain a constant airflow setpoint.
2. Critical environment control system suppliers not employing constant volume venturi airflow control valves shall provide pneumatic tubing or electrical wiring as required for their devices.

G. Local Display Unit:

1. The control system shall have an optional local display option that allows monitoring and control of system variables to be displayed on a user interface terminal device.
2. The display unit shall have the ability to connect to the room level devices through a room integrator or BACnet compatible room monitor.
3. The display unit shall be powered by 24 VAC.
4. The local display unit shall have the provisions of being flush mounted or surface mounted directly to a standard electrical enclosure. Electrical conductors shall terminate inside the display module housing to a pluggable terminal block.
5. The enclosure shall be made from material that is resistant to chemicals that are typically used in the lab for wipe down and general cleaning agents.
6. The unit's exposed surfaces shall be chemically resistant to vaporized hydrogen peroxide (VHP), formaldehyde, chloride dioxide (clidox), percholoric acid, sodium hypochloride/hypochlorite 3-6% (bleach), and quaternary ammonium 7% in 1:128 tap water (ammonia).
7. The display unit shall be rated for use in areas where IP54 rating is required.
8. The display unit shall utilize a 7" diagonal touchscreen display with optional color schemes to adapt the display to various lighting conditions.
9. The display unit shall provide a means of entering and displaying a unique location descriptor (device ID).
10. The display unit shall allow access to pertinent flow, temperature, humidity, pressure data, occupancy and emergency mode control status, and current device or system alarm status. Data shall be viewable in units of measure appropriate for users of the system.

11. The display unit shall have the ability to display:

    a. Present value, which may be read directly off the network or conditioned with a fixed multiplier and/or offset to scale the value for the desired units of measure.
    b. Units of measure, which are configurable based on local user conventions.

12. Setpoints and editable control parameters shall be viewable on the view. The user shall have the ability to provide four levels of access. There shall be three levels of PIN code access to prevent unauthorized changes to setpoints and editable control parameters.
13. Monitor shall have the ability to locally display alarms for:

    a. Numeric high and low limits
    b. Binary inputs (alarm selectable for True or False state)
    c. Multistate alarms (alarmable on all but one state)

14. Alarms shall have adjustable volume and the ability to be muted for situations where a visual alarm is acceptable or an audible alarm is not desired.

H. Fume Hood Display:

1. The display screen shall be a color LCD resistive touch screen (240 x 320 RGB).
2. The touch screen shall support input configurations for fume hood operational parameters done at the touch panel and, at a minimum, include:

    a. Sash dimensions
    b. Hood ID
    c. Hood certification reminder
    d. Hood occupancy status
    e. Stopwatch/TIMER
    f. Message display

3. Hood configuration for the following properties shall be viewable and editable from the touch display:

    a. Sash dimensions
    b. Hood ID
    c. Hood certification reminder
    d. Hood occupancy status
    e. Stopwatch/timer
    f. Message display

4. The enclosure shall be made from material that is resistant to chemicals that are typically used in the lab for wipe down with non-solvent cleaning agents.
5. The unit's exposed surfaces shall be chemically resistant to vaporized hydrogen peroxide (VHP), formaldehyde, chloride dioxide (clidox), percholoric acid, sodium hypochloride**/**hypochlorite 3-6% (bleach), and quaternary ammonium 7% in 1:128 tap water (ammonia).
6. Two mechanical membrane buttons shall be provided at the front panel of the display to enable users to quickly activate emergency exhaust mode and mute without having to remove protective gloves.
7. Flush mount or recess mount shall be installation options.
8. A USB port shall be provided to support firmware and software upgrades and shall be covered to protect against moisture or corrosion.
9. A timer feature shall be provided to enable users to set specific durations for experiments and provide visual and audible alarms when the set time is expired.
10. The fume hood display shall have an available I/O at its associated valve controller that may be used to receive a 0 - 10 volt signal from a through-the-wall (TTW) sensor. The TTW shall not control the valve but provide a drift alert to indicate when the TTW sensor reading is out of range relative to the sash position face velocity value.
11. Power: The device shall be powered by 24 VAC $\pm$ 15% at 10VA, 50/60 Hz.

12. Configuration:

    a. Configuration shall be performed from the touch display and/or manufacturer's software tools.
    b. The device shall be capable of being added to an existing LON communication network.
    c. The device shall display fume hood performance data based on control logics embedded inside the valve controller.

13. Communication:

    a. The fume hood display unit shall be capable of communicating with the building FMCS via BACnet or LON.
    b. The device shall display fume hood performance data based on sash movements and valve controller performance.

14. Information Display:

    a. The device shall have the ability to indicate when the fume hood face velocity is within the normal operating range as well as energy saving, hood certification, hood ID, timer, and hood occupancy status.
    b. The device shall be configurable to display one of the following measurement units: cubic feet per minute (CFM), meters cubed per hour (m^3/h), liters per second (l/s), feet per minute (fpm), or meters per second (m/s).
    c. The device shall have the ability to display system errors caused by the airflow valve or sash travel.
    d. The device shall have the ability to indicate to users when the hood is due for recertification by stating on the LCD display "Hood Cert. Due MM/DD/YYYY".

15. Emergency (Purge) Exhaust:

    a. The display shall have a mechanical membrane button on the lower portion that, when pressed, will initiate an emergency (purge) exhaust mode in the attached fume hood valve(s).

        1) Button shall be mechanical so that users with rubber, nitrile, vinyl, latex, or other gloves can operate the emergency exhaust button.

    b. The emergency (purge) exhaust mode, when initiated, will send the attached fume hood exhaust valve(s) to either the maximum flow of the valve or another predefined flow (as configured in the fume hood valve).

16. Alarms:

    a. The device shall have the ability to show alarms on the main screen using visual and audible alerts.
    b. The main screen background color shall change to flashing red with text stating the type of alarm.
    c. In alarm state, the visual indication shall remain active until the event that triggered the alarm is removed or fixed.
    d. The audible alarm tone shall be cleared only when the event that triggered the alarm is removed or fixed.
    e. The device shall have an alarm muting option that silences the audible alarm for an adjustable time period when the mute button is pushed. If another alarm is generated during the mute period, the new alarm shall override the mute delay and the alarm shall sound again.
    f. The device shall have the ability to customize audible alarms levels and customize mute duration.
    g. Users shall have the ability to change the volume of the alarm tone to low, medium, or high.

h. The device shall have the ability to show diversity alarm.

1) Diversity alarm shall be generated by the valve or from the FMCS system.
2) No audible tone for diversity alarm shall be generated at the fume hood display.

17. Energy Conservation:

a. The device shall have the ability to enable fume hood hibernation mode.

1) When activated, with the sash fully closed and no chemicals present in the hood, the exhaust flow through the fume hood goes to the minimum allowed by the exhaust valve (or shutoff where available).
2) The mode shall be initiated by a sequence including entering the menu and a password on the touch display, an external momentary switch input to the fume hood controller, or a network command via FMCS or BAS.
3) When activated, the LCD display shall show "Hood in Hibernation" and the exhaust valve shall move to its minimum position or shutoff position.
4) Safety shall be built into the hibernation mode whereby opening the fume hood sash shall automatically return the fume hood exhaust to an in-use operating volume as determined by the sash sensor. Fume hood hibernation shall be a point that can be integrated to the FMCS.

b. The device shall provide nighttime energy waste alarming to generate a visual and audible alarm to indicate that the fume hood sash is open beyond its minimum flow position and the lights in the room are off.

1) When activated, the LCD display shall show "Energy Waste Close Sash" and the audible alarm shall sound until the sash is closed.
2) The light levels at which the alarm is both initiated and cancelled shall be configurable.

c. The device shall provide sash energy waste alarming that generates a visual and audible alert to notify when the fume hood sash is open beyond a configurable set position and no one is in front of the fume hood.

1) When activated, the LCD display shall show "Energy Waste Close Sash" and remain until the sash is closed.

18. Security: End users shall have the ability to enable a PIN pass code to prevent unauthorized changes to sash heights, airflow settings, and other editable parameters.
19. Compliance:

a. The unit shall be certified as meeting regulatory compliance with CE, CUL, and rohs.
b. The unit shall be suitable for use with non-solvent wipe down and is designed to meet IP44 test standards.
c. The device shall comply with Part 15 of the FCC Rules. Operation is subject to the following two conditions:

1) This device shall not cause harmful interference.
2) This device shall accept any interference received, including interference that may cause undesired operation.

20. Environment:

a. The operating temperature range shall be between 32 - 122°F.

2.4 PERFORMANCE/DESIGN CRITERIA

A. Each dedicated critical environment control system shall support a minimum of 20 network controlled airflow devices.

B. The system shall employ individual average face velocity controllers that directly measure the area of the fume hood sash opening and proportionally control the hood's exhaust airflow to maintain a constant face velocity over a minimum range of 20% to 100% of sash travel. The corresponding minimum hood exhaust flow turndown ratio shall be 5 to 1.

C. The hood exhaust airflow control device shall respond to the fume hood sash opening by achieving 90% of its commanded value within one second of the sash reaching 90% of its final position (with no more than 5% overshoot/undershoot) of required airflow. Rate of sash movement shall be from 1 to 1-1/2 feet per second.

D. The hood exhaust airflow control device shall be switched automatically between in-use and standby levels based on the operator's presence immediately in front of the hood. A presence and motion sensor shall activate the switching. The airflow control device shall achieve the required in-use commanded value in less than one second from the moment of detection with no more than a 5% overshoot or undershoot.

E. The system shall maintain specific airflow (± 5% of signal within one second of a change in duct static pressure) regardless of the magnitude of the pressure change, airflow change or quantity of airflow control devices on the manifold (within 0.3" to 3.0" wc).

F. The system shall use volumetric offset control to maintain room pressurization. The system shall maintain proper room pressurization polarity (negative or positive) regardless of any change in room/system conditions, such as the raising and lowering of any or all fume hood sashes or rapid changes in duct static pressure. Systems using differential pressure measurement, vortex shedding measurement, or velocity measurement to control room pressurization are unacceptable.

G. The system shall maintain specific airflow (± 5% of signal) with a minimum turndown as specified in Components, Airflow Control Device/ Venturi Valve - General above to ensure accurate pressurization at low airflow and guarantee the maximum system diversity and energy efficiency.

H. Airflow Control Sound Specification:

1. The critical environment control system manufacturer shall provide comprehensive sound power level data for each size airflow control device. All data shall be obtained from testing in accordance with ASHRAE/ANSI Standard 130, Methods of Testing Air Terminal Units.
2. All proposed airflow control devices shall include discharge, exhaust, and radiated sound power level performance.
3. If the airflow control device cannot meet the sound power levels required to achieve the sound criteria appropriate for the space, as determined by the Architect/Engineer, a properly sized sound attenuator must be used. All sound attenuators must be of a packless design (constructed of at least 18 gauge 316L stainless steel when used with fume hood exhaust) with a maximum pressure drop at the device's maximum rated flow rate not to exceed 0.20"wc.

2.5 OPERATION SEQUENCES

A. The airflow control devices shall utilize distributed control architecture to perform room-level control functions. Control functions shall include, at a minimum, volumetric offset pressurization, temperature, humidity control, as well as respond to hood flow demands, occupancy, and emergency control commands.

B. Volumetric Offset Pressurization Control:

1. The control system shall control supply and auxiliary exhaust airflow devices to maintain a volumetric offset (either positive or negative). Offset shall be maintained regardless of any change in flow or static pressure (within specified range for medium or low pressure valves). This offset shall be field adjustable and represents the volume of air that will enter (or exit) the room from the corridor or adjacent spaces.
2. The pressurization control algorithm shall sum the flow values of all supply and exhaust airflow devices and command appropriate controlled devices to new setpoints to maintain the desired offset. The offset shall be adjustable as a configurable parameter in the critical environment control system as set by startup technician or FMCS /BAS.

C. Temperature Control:

1. Standard Primary Temperature Control:

a. The control system shall regulate the space temperature through a combination of volumetric thermal override and control of reheat coils and/or auxiliary temperature control devices. The control system shall support the separate temperature zones for each pressurization zone as indicated on the drawings. Separate cooling and heating setpoints shall be writeable from the FMCS, with the option of a local offset adjustment.
b. Temperature control shall be implemented through independent primary cooling and heating control functions. Primary heating shall be provided through the use of a modulating control of a properly sized reheat coil. Primary cooling shall be provided as a function of volumetric override or through auxiliary modulating control of a chilled water valve. Volumetric override while maintaining required offset to deliver room pressurization requirements will command both supply and general exhaust valves to maintain desired offset as a high select zone control. Volumetric cooling override may be staged before or after chilled water control valve.

2. Auxiliary Temperature Control:

a. The auxiliary modulating temperature control function shall offer the option of either heating or cooling mode and to operate as either a standalone temperature control loop or staged to supplement the corresponding primary temperature control loop.

3. Advanced Temperature Control (ATC) or Cascade Control:

a. The primary temperature control loop for the lab is based on a comparison between the discharge air temperature and the setpoint for the discharge air. The space temperature measured by a wall sensor is used to reset the setpoint for discharge air. The setpoint may be calculated automatically by using "Adaptive Set Point Range". Another method enabling "Exhaust Air Temperature Adjustment" will calculate the difference between space temperature and exhaust temperature (within 2.7°F) to reset the setpoint for the discharge air. The reset schedule for the setpoint is driven by a small window of temperature above and below the desired room temperature in the space.

4. Thermal Anticipatory Control (BTU Compensation) Thermal:

a. Anticipatory control monitors discharge air temperature sensors, space temperature sensors, and discharge airflow to respond to significant (programmable) changes in airflow to immediately adjust temperature control.

5. Chilled Beam Control:

a. Chilled beam control shall be offered to control temperature in a space. Chilled beam control must have the ability to be turned off and/or reset if the condensate level rises over a given point. The condensate switch can reset automatically, use a timed latch, or FMCS command to reset.

D. Humidity Control:

1. The control system shall have an embedded humidity control function that allows the monitoring and control of the relative humidity level in the pressurized zone. The airflow devices shall have the ability to monitor the relative humidity level of the space and, based on an FMCS writeable setpoint, develop a control signal to drive one or the other humidification or dehumidification control circuits.
2. The humidity control loop(s) shall share a common setpoint, with a configurable deadband adjustment to prevent the humidification and dehumidification control functions to operate at the same time. A dew point sensor contact can be used to manually reset or disable humidification/dehumidification output as "Humidity PID Reset". The contact can reset automatically, use a timed latch, or FMCS command to reset.

E. Occupancy Control:

1. The control system shall have the ability to change the minimum ventilation and/or temperature control setpoints, based on the occupied state, in order to reduce energy consumption when the space is not occupied. The occupancy state may be set by either the FMCS as a scheduled event or through the use of a local occupancy sensor or switch. The control system shall support a local occupancy override button that allows a user to override the occupancy mode and set the space to occupied for a predetermined interval. The override interval shall be configurable from one to 1440 minutes. The local occupancy sensor/switch or bypass button shall be given priority over an FMCS command.

F. Emergency Mode Control:

1. The control system shall provide a means of overriding temperature and pressurization control in response to a command indicating an emergency condition exists, and airflow control devices are to be driven to a specific flow setpoint. The system shall support up to four emergency control modes (zone or valve level). The emergency control modes may be initiated either by a local contact input or FMCS command. Valve level emergency modes can be individually programmed on each valve as one of four emergency control modes. Zone level emergency modes shall drive supply and exhaust valves to maintain or ignore zone offset (excludes control of hood valves).
2. Once an emergency mode is invoked, pressurization and temperature control are overridden for the period that the mode is active. Emergency modes shall have a priority scheme allowing a more critical mode to override a previously set condition.

G. Local Alarm Control:

1. The control system shall provide the means of summing selective alarm activity at the room-level network and generating a local alarm signal. The local alarm signal may be directed to any available output as well as to the FMCS. The alarm mask may be configured differently for each room-level system.

H. Shutoff Control:

1. The control systems shall provide means of commanding airflow devices to shutoff sequence in one of four modes.

   a. Emergency Mode Control: The shutoff sequence can be initiated locally through a universal input or remotely from the FMCS or other controller such as the local display unit (LDU) using emergency mode(s). Fume hood airflow devices cannot be controlled locally using a universal input (refer to mode 2 below).
   b. Hibernation Mode Control: The shutoff sequence can be initiated on a fume hood airflow device using hibernation mode in conjunction with an FHM631 fume hood monitor or a Sentry fume hood display in one of three methods: local contact closure, pushbutton sequence using faceplate of fume hood monitor, or remotely via FMCS. If the sash on the fume hood is moved when hood is in hibernation mode, hood will automatically return to normal operation with no interaction to the fume hood monitor or fume hood display. Hibernation or decommission modes that require the occupant to enter the fume hood monitor or fume hood display menu or settings to return to normal control mode are unacceptable.

c. Auto Gex Shutoff Mode Control: The shutoff sequence can be initiated on a general exhaust (Gex) airflow device in a lab environment when the total non-Gex exhaust airflow satisfies minimum air change rate and cooling demand for a period greater than 60 seconds. Shutoff must be enabled on the general exhaust airflow device.
d. IAQ Mode Control: The shutoff sequence can be initiated when exhaust airflow is distributed between a general exhaust and return airflow device. If shutoff is enabled, the general exhaust airflow device will shut when return ratio is 100% and the return airflow device will shut when the return ratio is 0%.

I. Diversity Alarm:

1. The control system shall have the ability to monitor the airflow values for the pressurized space and generate an alarm signal in the event the total exhaust flow exceeds a predetermined threshold. The diversity alarm is intended to allow the user to take diversity in the design and generate an alarm condition in the event the diversity threshold is compromised. This function must be available in either an integrated or standalone system.

J. Fume Hood Control:

1. Airflow devices intended to control the face velocity of a fume hood shall have the ability to interface directly with the fume hood monitoring device. The airflow control device shall:

a. Accept command inputs to regulate the flow accordingly and make this command value available to the FMCS.
b. Accept a sash position signal and make this value available to the FMCS.
c. Accept a presence sensor (PS) usage based control signal to indicate user presence and make this signal available to the FMCS. Wide range motion sensors or Doppler radar motions sensors are not acceptable.
d. Provide a flow feedback signal to the fume hood monitor that may be used for calculating face velocity or to confirm the airflow device has achieved the proper flow rate and make this value available to the FMCS.
e. Provide alarm signals to the fume hood monitor in the event the airflow device is unable to achieve the proper flow rate, there is a loss of static pressure indicating improper fan operation, or there is a loss of power to the airflow control device in order to provide a local alarm indication.
f. The fume hood airflow control device shall respond to changes in sash position and user presence within one second, without hunting, in order to provide a constant 80 FPM face velocity when the fume hood is in use.

K. The critical environment control system shall provide control for all valves required per the plans and specs.

L. All points shall be available through the interface to the FMCS for trending, archiving, graphics, alarm notification, and status reports. Critical environment control system performance (speed, stability and accuracy) shall be unaffected by the number of points being monitored, processed, or controlled.

M. All devices/controllers shall be native BACnet or LON.

N. Refer to the FMCS specification for the required input/output summary for the necessary points to be monitored and/or controlled.

2.6 INTERFACE TO FACILITY MANAGEMENT AND CONTROL SYSTEMS

A. The critical environment control system network shall have the capability of digitally interfacing with the FMCS. The required software interface drivers shall be developed and housed in one or more dedicated interface devices furnished by the supplier. Open protocol native BACnet is preferred. For providers who cannot offer native BACnet, a detailed submittal or BACnet integration requirements shall be provided with submittal data.

B. All room-level points shall be available to the FMCS for monitoring or trending. The critical environment control system integrator and/or room manager shall maintain a cache of all points to be monitored by the FMCS. The room-level airflow control devices shall continually update this cache.

C. Room Level Integration:

1. Device shall be non-proprietary. No special tools shall be required to make the system available.
2. If the room level integration device drops off the network or loses power, it shall not cause the zone balance, temperature control, or fume hood devices to lose control. The room level valve devices should operate independently of the room level integration device. Space controller, room controller with hardwired control of hood, general exhaust and supply valves, or PLC with hardwired control of fume hood, general exhaust or supply valves for zone balance, temperature control, room offset, etc. are not acceptable.
3. Room level controller shall be able to integrate to FMCS through BACnet/IP, BACnet/Ethernet, BACnet MS/TP, or LON through onboard communication adapters and shall be field configurable/upgradable.

D. Room Manager:

1. Critical environment integration shall support distributed network architecture from room level BACnet MS/TP segment or LON FTT-10 bus to a dedicated BACnet MS/TP segment, building BACnet/Ethernet, or BACnet/IP building backbone using single or multiple IP addresses. Backbone communication protocol must be field selectable/upgradable.
2. Devices in a room or zone will operate independent of building level communications, maintaining integrity of the airflow. Critical environment control system building level communication, or loss of, will not disrupt the communication between devices in a room or zone.
3. Critical environment control system integration shall provide an easy means to access room level device health status at a room-by-room or building-wide level.
4. Critical environment control system integration shall provide an easy means to access test and balance functions at a room-by-room basis. Test and balance functions should include:

   a. Setting the devices in the room to various conditions in order to read airflow.
   b. Manually override the outputs for testing purposes.
   c. Adjust airflow to meet field acceptance tests.

5. Critical environment control system integration must work with the FMCS for long-term trending.
6. Critical environment control system integration shall provide optional software to manage local backup and restore, entire site device management, building-wide test and balance functions, building-wide diagnostic tools, and building-wide configuration tools. Software shall be field upgradable to support graphical dashboard displays.

2.7 ACTIVE PRESSURE CONTROL SYSTEMS

A. Each pressurized space that requires active pressure control shall have a dedicated airflow space pressurization control system to control the airflow in and out of the space to maintain the desired pressurization level, either positive or negative. The space pressure control system shall function as an interactive control system consisting of variable volume flow control devices, all of which shall be under control with flow feedback into the zone pressure control function. The space pressure control system shall vary the amount of makeup/supply or exhaust/return air into or out of the room to operate the space at the lowest possible airflow rates necessary, to maintain temperature control, achieve minimum ventilation rates, and maintain space pressurization in relation to adjacent spaces (positive or negative). The space pressurization airflow control system shall operate as a standalone system with the ability to operate with the building management system (FMCS). An optional locally mounted user interface terminal shall be available to allow room-level control variables to be displayed, and, where appropriate, edited to adjust control operation.

B. Pressure Control:

1. The space pressure control shall maintain a minimum ventilation flow rate to obtain the desired air changes per hour. Two minimum ventilation flow setpoints shall be provided: one for occupied periods and one for unoccupied periods; which setpoint is used shall be a function of the occupancy control state. The minimum ventilation setpoints shall be configurable as either fixed values or writable from the FMCS.
2. The pressure control function shall maintain a fixed flow for either the supply or exhaust side devices under control and modulate the controlled exhaust or supply side devices in order to maintain space pressurization. The space pressure control system shall provide for a base fixed volumetric offset setpoint to ensure directional airflow, even if the pressure control function is not running. The pressure control variable shall be configurable to have either or both a filtered control signal and/or a controlled ramp time to dampen the control signal, if required.

C. Performance:

1. Each airflow control device shall maintain specific airflow (± 5% of signal within one second of a change in duct static pressure), regardless of the magnitude of the pressure change, airflow change, or quantity of airflow control devices on the manifold (within 0.3" to 3.0" wc).
2. After proper commissioning, the space pressurization control system shall maintain space pressurization capable of controlling to ± 0.01"wc of the desired setpoint.
3. The airflow control system shall maintain specific airflow (± 5% of signal) with a minimum 8 to 1 turndown to ensure accurate pressurization at low airflow and guarantee the maximum system diversity and energy efficiency.
4. Provide all controller electronics within finished steel enclosures mounted on the air valves or wall-mounted enclosures if shown on plans.

2.8 ADVANCED PRESSURE MONITOR (SENSOR, TRANSMITTER, DISPLAY)

A. Provide pressure-to-current transmitters with the following minimum specifications:

1. Color, touch-screen display
2. Resistant to spray washdown (rated for use in IP54 environments)
3. Multi-function input signal of 0-10VAC, 0-5VAC or 4-20 mA
4. Standard accuracy RSS of at least +/- 0.5% full scale (non-linearity, hysteresis, and non-repeatability)
5. Optional high accuracy RSS of at least +/- 0.25% full scale (non-linearity, hysteresis, and non-repeatability)
6. Integral zero and span adjustment
7. Temperature effect on zero/span shift ± 0.03 % FS/°F
8. Pressure ranges, selected by Architect/Engineer, shall be up to (-1.0" to +1.0"wc)
9. Temperature range: 32 to 120°F
10. Programmable visual alarm and adjustable audible alarm
11. Alarm contact output, SPDT, contact rating of 2.0A @ 30VAC/VAC, 0.6A @ 125VAC

B. Products:

1. Sensors are required as indicated on the drawings.

2.9 ROOM AIR PRESSURE SENSOR PLATE

A. Provide shielded static air probes for sensing room pressure levels. Probes shall be flush mounted in a standard 2" x 4" electrical box.

B. The pressure-sensing tubing shall be connected to the top of the probe with 1/4" tubing. Tubing shall also be extended from the pressure sensor to a stable common pressure reference port.

C. The exact placement of the sensor plates and means of establishing a stable common reference pressure shall be determined by the Architect/Engineer.

2.10 PRESSURE

A. Door status switches with SPDT form C contacts with the following ratings shall be provided:

1. The maximum switching voltage is 30 volts at 0.1 A.
2. The maximum switching current is 0.25 A at 12 V.

B. Door switches shall be installed and mounted per the manufacturer's recommendation.

C. Products:

1. GE Sentrol Wide Gap Switch Model 1078 Series

2.11 CONTROL FUNCTIONS

A. The airflow control devices shall include, at a minimum, pressurization, temperature, and humidity control, as well as respond to occupancy and emergency control commands.

B. Active Pressurization Control:

1. The space pressure control system shall control supply and exhaust airflow devices to maintain at a minimum ± 0.01"wc. The pressurization control algorithm shall sum the flow values of all supply and exhaust airflow devices and command appropriately controlled devices to new setpoints to maintain the desired offset. The offset shall be adjustable.
2. The pressurization control algorithm shall support the ability to regulate the distribution of total supply flow across multiple supply airflow control devices to optimize air distribution in the space.

PART 3 - EXECUTION

3.1 INSTALLATION

A. The Facility Management and Control System (FMCS) or Building Automation System (BAS) Contractor shall install the sash sensors, interface boxes, presence and motion sensor, and fume hood monitor on the fume hood under initial supervision of the supplier. Reel-type sash sensors and their stainless steel cables shall be hidden from view. Bar-type sash sensors shall be affixed to the individual sash panels, or use of fixed sash sensors with take-up reels is also permitted. Sash interface boxes with interface cards shall be mounted in an accessible location. Sidewall sensors are acceptable for use to control the fume hood valves. Hot wire thermal anemometer type side wall sensors are not acceptable. The sidewall sensor must maintain a speed of response per ANSI-Z95.

B. The FMCS Contractor shall install all critical environment control system devices in an accessible location.

C. The FMCS Contractor shall install an appropriately sized and fused 24 VAC transformer suitable for NEC Class II wiring.

D. All cable shall be furnished and installed by the FMCS Contractor. The FMCS Contractor shall terminate and connect all cables as required. The FMCS Contractor shall utilize cables specifically recommended by the airflow controls supplier.

E. The Mechanical Contractor shall install all airflow control devices in the ductwork and shall connect all airflow control valve linkages.

F. The Mechanical Contractor shall provide and install all reheat coils, neutralizers, silencers, and transitions.

G. The Mechanical Contractor shall provide and install insulation as required.

H. Each pressurization zone shall have either a dedicated, single-phase primary circuit or a secondary circuit disconnect.

3.2 SYSTEM STARTUP

A. System startup shall be provided by a factory trained and authorized representative of the critical environment control system manufacturer. Startup shall include calibrating the fume hood monitor and any combination sash sensing equipment, as required. Startup shall also provide electronic verification of airflow (fume hood exhaust, supply, makeup, general exhaust, or return), system programming and integration to FMCS (when applicable).

B. The Balancing Contractor shall be responsible for final verification and reporting of all airflows. For all field flow measurement devices, the balancer shall produce a flow report that documents field flows vs. device flow and associated error. This shall be tabulated for each device location at several flows including min and max. Cost and responsibility to meet the specified performance shall be carried by the ACS.

3.3 CLOSEOUT ACTIVITIES

A. Training

1. The critical environment control system supplier shall furnish a minimum of eight (8) hours of Owner training by factory trained and certified personnel. The training will provide an overview of the job specific airflow control components, verification of initial fume hood monitor calibration, general procedures for verifying airflows of air valves, and general troubleshooting procedures.
2. Operation and maintenance manuals, including as-built wiring diagrams and component lists, shall be provided for each training attendee.

END OF SECTION 23 09 20

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SECTION 23 21 00 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Pipe and Pipe Fittings

B. Valves

C. Check Valves

D. Strainers

E. System Piping Schedule

1.2 QUALITY ASSURANCE

A. Valves: Manufacturer's name and pressure rating marked on valve body. Remanufactured valves are not acceptable.

B. Welding Materials, Procedures, and Operators: Conform to ASME Section 9, ANSI/AWS D1.1, and applicable state labor regulations.

1.3 SUBMITTALS

A. Submit product data under provisions of Section 23 05 00. Include data on pipe materials, fittings, valves, and accessories. Include manufacturers' support spacing requirements for plastic piping.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Store and protect piping to prevent entrance of foreign matter into pipe and to prevent exterior corrosion.

B. Deliver and store valves in shipping containers with labeling in place.

1.5 COORDINATION DRAWINGS

A. Reference Coordination Drawings article in Section 23 05 00 for required hydronic systems electronic CAD drawings to be provided to Coordinating Contractor for inclusion into composite coordination drawings.

PART 2 - PRODUCTS

2.1 STEEL PIPE (ABOVE GRADE)

A. Design Pressure 125 psig, Maximum Design Temperature 225°F (230°F for grooved couplings).

B. Black Steel; Standard Weight; Welded or Flanged Joints:

1. Pipe: Standard weight black steel, beveled ends, ASTM A53, Type E or S, Grade B.
2. Joints: Butt-welded or flanged.
3. Fittings: Standard weight wrought steel, butt-welding type, ASTM A234, ASME B16.9.
4. Flanges: Class 150 forged steel, welding neck or slip-on, ASTM A181 or A105, Class 60, ASME B16.5 up to 24" and B16.47 above 24". ASME B16.1 for flanges mating with flat face equipment flanges. Flange face seal weld (backweld) is required for slip-on flanges.

C. Black Steel; Standard Weight; Welded:

1. Design Pressure: 125 psi. Maximum Design Temperature: 1000°F
2. Pipe: Standard weight black steel, beveled ends, ASTM A53.
3. Joints: Butt welded.
4. Fittings: Standard weight seamless steel, butt weld type, ASTM A234, Grade WPB, ANSI B16.9.

2.2 COPPER PIPE (ABOVE GRADE)

A. Design Pressure 125 psig. Maximum Design Temperature 225°F.

B. Copper Pipe; Type L; Soldered Joints:

1. Tubing: Type L drawn temper seamless copper tube, ASTM B88.
2. Joints: Solder with Type 95-5 solder. 50-50 solder is not acceptable.
3. Fittings: Wrought copper solder joint, ASME B16.22.

C. Copper; DWV; Soldered:

1. Tubing: DWV drawn temper seamless copper drainage tube, ASTM B306.
2. Joints: Solder with Type 95-5 solder. 50-50 solder is not acceptable.
3. Fittings: ASME B16.23 cast brass, or ASME B16.29 solder wrought copper.

2.3 DUCTILE IRON PRESSURE PIPE (UNDERGROUND)

A. Design Pressure 200 psi, Maximum Design Temperature 150°F.

B. Ductile Iron Pipe; Pressure Water Pipe; Mechanical Joints:

1. Pipe: Ductile iron pressure water pipe, ANSI/AWWA C151/A21.51, 200 psi pressure class, cement-mortar lined per ANSI/AWWA C104/A21.4, mechanical joints.
2. Fittings: Ductile iron, ANSI/AWWA C110/A21.10 or ANSI/AWWA C153/A21.53, 200 psi pressure class, cement-mortar lined per ANSI/AWWA C104/A21.4, mechanical joints.

2.4 PVC PRESSURE PIPE (UNDERGROUND)

A. Maximum Design Temperature 140°F.

B. PVC Pressure Pipe; Class 200, C900; Push-On/Solvent Joint:

1. Pipe: PVC pressure pipe, Class 235 psi ANSI/AWWA C900 approved, bell and spigot ends.
2. Joints: Push-On Type ASTM D3139, elastomeric ring seal per ASTM F477, bevel spigot ends
3. Fittings: PVC bell and spigot type, Class 150; 235 psig (1620 rating, ASTM D1784.

2.5 HDPE PRESSURE PIPE (UNDERGROUND)

A. Design Pressure 200psi at 73F

1. This pipe will carry a warranty of no less than 50 years. Submit written warranty on piping.

a. Each pipe shall be durably marked with the manufacturer's name, nominal size, pressure rating, relevant ASTM standards, cell classification number, and date of manufacture.
b. Pipe Sizes: NSF 14 certified iron pipe size.
c. Manufacturers:

1) HDPE Inc.
2) Chevron Phillips Driscoplex 4100.
3) PolyPipe PolyPlus.

2. Joints: Fusion welded.
3. Fittings: Socket type or butt/saddle fusion. Pipe fittings shall meet the requirements of ASTM D2683, ASTM D2513, or ASTM D3261. Each fitting shall be identified with the manufacturer's name, nominal size, pressure rating, relevant ASTM standards, and date of manufacturer.

2.6 VALVES

A. Shutoff Valves:

1. For pipe systems where mechanical press connections are allowed, shutoff valves with mechanical press connections are acceptable subject to the requirements in the paragraphs below.
2. Ball Valves:

a. BA-1 (Steel and Copper): 3" and under, 125 psi saturated steam, 600 psi WOG, full port, screwed or solder ends , Navy bronze body of a copper alloy containing less than 15% zinc, stainless steel ball and trim, Teflon seats and seals.

1) Provide extended shaft with operating handle of non-thermal conductive material and protective sleeve that allows operation of valve, adjustment of the packing, and adjustment of the memory stop without breaking the vapor seal or disturbing the insulation for all valves in insulated piping.
2) Provide lock out trim for all valves opening to atmosphere installed in domestic water piping over 120°F, heating water piping over 120°F, steam, condensate, boiler feed water piping, compressed air piping and gasoline/kerosene piping, and as indicated on the drawings. Solid extended shaft is not required on valves with lock out trim.

b. BA-15 (Plastic): 2-1/2" to 6", 80 psi at 100°F, 25 psi at 140°F, socket weld, PVC, true union ball valve with PTFE ball seats, EPDM O-ring seals.

1) Manufacturers:

a) George Fischer 370
b) R&G Sloane
c) Asahi Omni
d) Nibco Tru-bloc.

3. Butterfly Valves:

a. BF-1:

1) 2-1/2" thru 6", 175 psi CWP, elastomers rated for 20°F to 225°F continuous and 250°F intermittent at 125 psig, fully lugged or grooved end, ductile or cast iron body (not in contact with fluid); bronze, aluminum-bronze or EPDM coated ductile iron disc; EPDM seat, stainless steel stem, extended neck, 175 psi bubble-tight, bi-directional dead-end shutoff without backing flange or nuts and with cap screws extending to centerline of valve body (for pipe extension without draining system), infinite position locking operator with memory stop up to 6" size. Cv of at least 1580 in 6" size.
2) Manufacturers:

a) Center Line Series 200
b) Keystone #222
c) Watts #DBF-03-121-1P
d) Nibco N200 Series or LD2000 Series
e) Milwaukee CL series
f) Hammond 5200 series.

3) 8" thru 12", 175 psi CWP, elastomers for 20°F to 225°F at 130 psi, fully lugged end, ductile or cast iron body (not in contact with fluid), bronze, EPDM coated ductile iron or aluminum-bronze disc, EPDM seat, stainless steel stem, extended neck, 175 psi bubble-tight, bi-directional dead-end shutoff without backing flange or nuts and with cap screws extending to the centerline of the valve body (to permit pipe extension without draining system), weatherproof gear operator.
4) Manufacturers:

a) Center Line Series 225
b) Watts #DBF-03-121-1G
c) Nibco N200 Series or LD2000 Series
d) Milwaukee CL series, Hammond 5200 series.

2.7 THROTTLING VALVES

A. Throttling Valves (Steel):

1. For pipe systems where mechanical press connections are allowed, throttling valves with mechanical press connections are acceptable subject to the requirements in the paragraphs below.
2. Globe Valves (Steel Pipe):

a. GL-1: 3" and under, 125 psi saturated steam, 300 psi WOG, screwed, bronze.

1) Manufacturers:

a) Crane #7TF
b) Stockham #B22T
c) Walworth #95
d) Milwaukee #590
e) Hammond #IB413T
f) Watts #B-4010-T
g) or NIBCO #T-235.

b. GL-2: 4" thru 10", 125 psi S @ 353°F, 200 psi WOG @ 150°F, flanged, iron body, bronze mounted.

1) Manufacturers:

a) Crane #351
b) Hammond #IR116
c) Stockham #G-512
d) Walworth #906F
e) Milwaukee #F2981
f) Watts #F-501
g) or NIBCO #F-718.

3. Globe Valves (Copper Pipe):

a. GL-5: 2" and under, 125 psi saturated steam, 300 psi WOG, solder, bronze.

1) Manufacturers:

a) Hammond #IB423
b) Stockham #B24T
c) Milwaukee #1590
d) Watts #B-4011-T
e) NIBCO #S-235.

4. Ball Valves (Steel and/or Copper):

a. BA-9: 2" and under, 125 psi saturated steam, 600 psi WOG, standard port, screwed, Navy bronze body and ball of copper alloy containing less than 15% zinc, chrome plated or stainless steel ball, Teflon seats and seals with memory stop.

5. Butterfly Valves:

a. BF-4:

1) 2-1/2" thru 6", 175 psi CWP, elastomers rated for 20°F to 225°F continuous and 250°F intermittent at 125 psig, fully lugged or grooved end, ductile or cast iron body (not in contact with fluid); bronze, aluminum-bronze or EPDM coated ductile iron disc; EPDM seat, stainless steel stem, extended neck, 175 psi bubble-tight, bi-directional dead-end shutoff without backing flange or nuts and with cap screws extending to centerline of valve body (for pipe extension without draining system), infinite position locking operator with memory stop up to 6" size. Cv of at least 1580 in 6" size.
2) Manufacturers:

a) Victaulic #300
b) Center Line Series 200
c) Keystone #222
d) Watts #DBF-03-121-1P
e) NIBCO LD2000 Series
f) Milwaukee CL Series
g) Hammond 5200 Series

3) 8" thru 12", 175 psi CWP, elastomers for 20°F to 225°F at 130 psi, fully lugged end, ductile or cast iron body (not in contact with fluid), bronze, EPDM coated ductile iron or aluminum-bronze disc, EPDM seat, stainless steel stem, extended neck, 175 psi bubble-tight, bi-directional dead-end shutoff without backing flange or nuts and with cap screws extending to the centerline of the valve body (to permit pipe extension without draining system), weatherproof gear operator.

4) Manufacturers:

a) Center Line Series 200
b) Keystone #222
c) Watts #DBF-03-121-1G
d) NIBCO LD2000 Series
e) Victaulic #300
f) Milwaukee CL Series
g) Hammond 5200 Series

2.8 LOCK OUT TRIM

A. Provide lock out trim for all quarter turn valves opening to atmosphere installed in heating water piping over 120°F and as indicated on the drawings.

2.9 CHECK VALVES

A. For pipe systems where mechanical press connections are allowed, check valves with mechanical press connections are acceptable subject to the requirements in the paragraphs below.

B. CK-1: Check Valves (Steel Pipe); 2" and under, 125 psi S @ 353°F, 200 psi WOG @ 150°F, screwed, bronze, horizontal swing.

1. Manufacturers:

a. Crane #37
b. Hammond #IB904
c. Walworth #406
d. Milwaukee #509
e. Watts #B-5000
f. or NIBCO #T-413.

C. CK-13: Check Valves (Steel Pipe); 2-1/2" thru 12", 200# WOG, double disc wafer type, non-slam silent check, iron body, bronze or aluminum-bronze discs, 316SS shaft and spring, Viton, EPDM or BUNA-N, Cv of at least 700 in 6" size.

1. Manufacturers:

a. NIBCO W-920-W
b. Crane Duo-Chek
c. Victaulic V715

D. CK-7: Plastic; All sizes, 125# WP @ 75°F , socket weld, normal impact PVC, ball type. Cabot Corp.

2.10 STRAINERS

A. All strainers to be provided with blow down valve with hose thread end cap and chain.

B. ST-1: Bronze body, screwed ends, screwed cover, 125 psi S @ 353°F, 200 psi WOG @ 150°F

1. Manufacturers:

a. Armstrong #F4SC
b. Metraflex #TS
c. Mueller Steam Specialty Co. #351
d. Sarco #BT
e. Watts #777
f. NIBCO T-122-A.

C. ST-2: Cast iron body, 125 lb. flanged ends, bolted cover, 125 psi S @ 353°F, 175 psi WOG @ 150°F.

1. Manufacturers:

a. Armstrong #A1FL
b. Metraflex #TF
c. Mueller Steam Specialty Co.#758
d. Sarco #CI-125
e. Watts #77F-D
f. Victaulic #732 or #W732
g. NIBCO F-721-A.

D. Unless otherwise indicated, strainers shall be Y-pattern and have stainless steel screens with perforations as follows

1. Pipe Size:

a. 1/4" - 2": 1/32" screen
b. 2-1/2" - 8": 1/16" screen
c. 10" and Up: 1/8" screen

E. Furnish pipe nipple with ball valve, threaded hose connection, and cap to blow down all strainer screens.

F. Use bronze body strainers in copper piping and iron body strainers in ferrous piping.

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. Remove all scale, rust, dirt, oils, stickers and thoroughly clean exterior of all bare metal exposed piping, hangers, and accessories in preparation to be painted.

D. Connect to all equipment with flanges or unions.

E. After completion, fill, clean, and treat systems. Refer to Section 23 25 00 for treatment.

3.2 SYSTEMS, PIPING, AND VALVE SCHEDULE

A. Heating Water (Above Grade - maximum 200°F unless noted otherwise below):

1. Copper Pipe; Type L; Soldered Joints: 2" and Under
2. Black Steel; Standard Weight: Welded or Flanged Joints: 2-1/2" and Over
3. Shutoff Valves: , BA-1, BF-1, BF-5
4. Throttling Valves: GL-1, GL-2, GL-5, BA-9, BF-4, BF-5
5. Check Valves: CK-1, CK-4, CK-13
6. Strainers: ST-1, ST-2

B. Chilled Water (Above Grade):

1. Copper Pipe; Type L; Soldered Joints: 2" and Under
2. Black Steel; Standard Weight: Welded or Flanged Joints:2-1/2" and Over
3. Shutoff Valves: , BA-1, BF-1, BF-5

4. Throttling Valves: GL-1, GL-2, GL-5, BA-9, BF-4, BF-5
5. Check Valves: CK-1, CK-4, CK-13
6. Strainers: ST-1, ST-2

C. Chilled Beam (Cooling) Water (Above Grade):

1. Copper Pipe; Type L; Soldered Joints: 2" and Under
2. Black Steel; Standard Weight: Welded or Flanged Joints:2-1/2" and Over
3. Shutoff Valves: BA-1, BF-1, BF-5
4. Throttling Valves: GL-1, GL-2, GL-5, BA-9, BF-4, BF-5
5. Check Valves: CK-1, CK-4, CK-13
6. Strainers: ST-1, ST-2

D. Glycol Water (Above Grade):

1. Copper Pipe; Type L; Soldered Joints: 2" and Under
2. Black Steel; Standard Weight: Welded or Flanged Joints:2-1/2" and Over
3. Shutoff Valves: , BA-1, BF-1, BF-5
4. Throttling Valves: GL-1, GL-2, GL-5, BA-9, BF-4, BF-5
5. Check Valves: CK-1, CK-4, CK-13
6. Strainers: ST-1, ST-2

E. Chilled Water (Underground):

1. Ductile Iron Pipe; Pressure Water Pipe; Mechanical Joints: All Sizes - only for transitions at exterior walls of buildings.
2. PVC Pressure Pipe; Class 165Class 200, C900; Push-On/Solvent Joint: All Sizes
3. HDPE; SDR 11; Heat Fusion Pipe Joining: All Sizes

F. Equipment Drains and Overflows:

1. Galvanized Steel; Schedule 40; Threaded Joints: All Sizes
2. Copper; DWV; Soldered: 4” (200 mm) and Under
3. Copper; Type M; Mechanical Press Connection: 4” (200 mm) and Under

3.3 TESTING PIPING

A. Test pipes underground or in chases and walls before piping is concealed.

B. Complete testing before insulation is applied. If insulation is applied before pipe is tested and a leak ruins the insulation, replace all damaged insulation.

C. Test the pipe with water at 1.5 times the design pressure but not less than 125 psig pressure. Hold pressure for at least two hours.

D. Test to be witnessed by the Architect/Engineer or their representative, if requested by the Architect/Engineer.

3.4 CLEANING PIPING

A. Assembly:

1. Prior to assembly of pipe and piping components, remove all loose dirt, scale, oil and other foreign matter on internal or external surfaces by means consistent with good piping practice subject to approval of the Architect/Engineer. Blow chips and burrs out of pipe before assembly. Wipe cutting oil from internal and external surfaces.

2. During fabrication and assembly, remove slag and weld spatter from both internal and external joints by peening, chipping and wire brushing to the degree consistent with good piping practices.
3. Notify the Architect/Engineer prior to starting any post erection cleaning operation in time to allow witnessing the operation. Properly dispose of cleaning and flushing fluids.
4. Prior to blowing or flushing erected piping systems, disconnect all instrumentation and equipment, open wide all valves, control valves, and balance valves, and verify all strainer screens are in place.

B. Chemical Cleaning:

1. Flush pipe and components with clean water until all discharge from system is clean. Maintain minimum velocities at all points of 5 feet/second for 30 minutes. Flow shall be in same direction as when system is in normal operation. Discharge shall be from low points of pipes, ends of headers and as otherwise needed to flush entire system. After flushing, all residual water shall be drained and/or blown out.
2. Add 2 pounds of trisodium phosphate per 100 gallons of system capacity. Use an alternate chemical if discharge of trisodium phosphate is not permitted. Maintain 150°F in the system if possible. If heat is not available, use 3 pounds per 100 gallons.
3. Drain the system after circulating the chemical cleaner for six hours at 150°F, or 12 hours at a lower temperature. Refill. Test a water sample. Drain and fill again if excessive cleaning chemicals remain and until water appears clear.
4. After each system has been cleaned and thoroughly flushed of pretreatment chemicals, it shall be immediately refilled with water and treated with chemical treatment as specified in Section 23 25 00. The system shall not be allowed to sit empty for any length of time.
5. When system water is clear, remove, clean and replace all strainers.
6. Water samples may be taken by the Architect/Engineer to verify a clean system. If system is not clean, the entire process, including chemical treatment specified in Section 23 25 00, shall be repeated at the Contractor's expense.
7. Chemical cleaning applies to the following systems:

   a. Heating Water
   b. Chilled Water

3.5 INSTALLATION

A. General Installation Requirements:

1. Route piping in orderly manner, straight, plumb, with consistent pitch, parallel to building structure, with minimum use of offsets and couplings. Provide only offsets required for needed headroom or clearance and needed flexibility in pipe system.
2. Install piping to conserve building space, and not interfere with other work.
3. Group piping whenever practical at common elevations.
4. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
5. Reducers are generally not shown. Where pipe sizes change at tee, the tee shall be the size of the largest pipe shown connecting to it. Where pipe sizes are not shown, the larger size in either direction shall continue through the fitting nearest to the indication of a smaller pipe size.
6. Install bell and spigot pipe with bells upstream.
7. Seal pipes passing through exterior walls with a wall seal per Section 23 05 29. Provide Schedule 40 galvanized sleeve at least 2 pipe sizes larger than the pipe.
8. Branch takeoffs shall be from the top side (if branch is two sizes smaller than main), or any angle from the horizontal plane to the top of piping.

B. Installation Requirements in Electrical Rooms:

1. Do not install piping or other equipment above electrical switchboards or panelboards. This includes a dedicated space extending 25 feet from the floor to the structural ceiling with width and depth equal to the equipment plus its required clearance space.

C. Installation Requirements in MRI (Magnetic Resonance Imaging - Healthcare):

1. All piping in MRI rooms shall be non-ferrous regardless of materials described on Part 2.

D. Valves/Fittings and Accessories:

1. Provide chain operators for all valves over 2" size that are over 10'-0" above finished floor. Extend to 7'-0" above finished floor.
2. Provide valve position indicator on all valves 10'-0" or greater above finish floor and not located above ceiling.
3. Provide clearance for installation of insulation, and access to valves and fittings.
4. Prepare pipe, fittings, supports, and accessories for finish painting.
5. Install valves with stems upright or horizontal, not inverted, except install manual quarter turn valves in radiation cabinets and all butterfly valves with stems horizontal.
6. Provide shutoff valves and flanges or unions at all connections to equipment, traps, and items that require servicing.
7. Provide flanges or unions at all final connections to equipment, traps and valves.
8. Arrange piping and piping connections so equipment may be serviced or totally removed without disturbing piping beyond final connections and associated shutoff valves.
9. Horizontal swing check valves may only be installed in horizontal position. Do not install horizontal swing check valves in upward or downward flow direction. Where upward or downward flow installation is required, use spring-assisted, non-slam check valve.

E. Fiberglass Piping:

1. Fiberglass pipe with epoxy adhesive shall be installed in conditioned space greater than 70°F, below 70°F heat assisted cure will be required. Refer to manufacturer's alternate installation methods for installation below 70°F and above 100°F.
2. Fiberglass pipe installed indoors shall require snorkel exhaust with activated charcoal filters to remove resin odor during fabrication.

F. Underground Piping:

1. Lay all underground piping in trenches. Provide and operate pumping equipment to keep trenches free of water.
2. Install thrust blocking and restraints on all underground piping at elbows and other changes in pipe direction.
3. Refer to Section 23 05 00 for Excavation, Fill, Backfill and Compaction requirements.

3.6 PIPE ERECTION AND LAYING

A. Carefully inspect all pipe, fittings, valves, equipment and accessories prior to installation. Immediately reject and remove from the job any items which are unsuitable, cracked or otherwise defective.

B. All pipe, fittings, valves, equipment and accessories shall have factory-applied markings, stampings, or nameplates sufficient to determine their conformance with specified requirements.

C. Exercise care at every stage of storage, handling, laying and erecting to prevent entry of foreign matter into piping, fittings, valves, equipment and accessories. Do not erect or install any unclean item.

D. During construction, until system is fully operational, keep all openings in piping and equipment closed at all times except when actual work is being performed on that item. Closures shall be plugs, caps, blind flanges or other items designed for this purpose.

E. Change direction of pipes only with fittings or pipe bends. Change size only with fittings. Do not use miter fittings, face or flush bushings, or street elbows. 2-1/2" and larger fittings shall be long radius type, unless otherwise shown on the drawings or specified. Construct welded elbows of angles not available as standard fittings by cutting and welding standard elbows to form smooth, long radius fittings.

F. Use full and double lengths of pipe wherever possible.

G. Unless otherwise indicated, install all inlet and outlet piping, including shutoff valves and strainers, to coils, pumps and other equipment at line size with reduction in size being made only at control valve or pump.

H. Cut all pipe to exact measurement and install without springing or forcing except in the case of expansion loops where cold springing is indicated on the drawings.

I. Do not create, even temporarily, undue loads, forces or strains on valves, equipment or building elements.

3.7 DRAINING AND VENTING

A. Unless otherwise indicated on the drawings, all horizontal pipes, including branches, shall pitch 1" in 40 feet to low points for complete drainage, removal of condensate, and venting.

B. Provide drain valves at all low points of water piping systems or where indicated on drawings for complete or sectionalized draining. Drain valves are defined above.

C. Use eccentric reducing fittings on horizontal runs when changing size for proper drainage and venting. Install all liquid lines with top of pipe and eccentric reducers in a continuous line.

D. Provide air vents at all high points and wherever else required for elimination of air in all water piping systems. Do not use automatic air vents in glycol systems unless they are piped to the fill tank.

E. Air vents shall be in accessible locations. If needed to trap and vent air in a remote location, a 1/8" pipe shall connect the tapping location to a venting device in an accessible location.

F. All vent and drain piping shall be of same materials and construction as the service involved.

3.8 BRANCH CONNECTIONS

A. Make branch connections with standard tee or cross fittings of the type required for the service unless otherwise specified herein or detailed on the drawings.

B. At the option of the Contractor, branch connections from headers and mains may be cut into black steel pipe using forged weld-on fittings.

C. Use of forged weld-on fittings is also limited as follows:

1. Must have at least same pressure rating as the main.
2. Header or main must be 2-1/2" or over.
3. Branch line is at least two pipe sizes under header or main size.

3.9 JOINING OF PIPE

A. Threaded Joints (Steel Pipe):

1. Ream pipe ends and remove all burrs and chips.
2. Protect plated pipe and valve bodies from wrench marks when making up joints.
3. Apply Teflon tape to male threads.

B. Flanged Joints (Steel Pipe):

1. Bronze flanges shall conform to B16.24 and ductile iron flanges to B16.42. Steel flanges shall be raised face except when bolted to flat face cast iron flange.

2. Bolting shall be ASTM A307 Grade B with bolts and heavy hexagonal nuts conforming to ASME B18.2.1 and B18.2.2.
3. Torque bolts in at least three passes, tightening to 1/3, 2/3, and final torque in a cross pattern with an indicating torque wrench for equal tension in all bolts.
4. Gaskets for flat face flanges shall be full-face type. Gaskets for raised faced flanges shall conform to requirements for "Group I gaskets" in ASME B16.5. All gaskets shall conform to ASME B16.21. Unless otherwise specified, gaskets shall meet the following requirements:

   a. Gasket material and thickness approved by manufacturer for intended service, chemical compatibility, pipe system test pressure, and operating temperature range.
   b. Maximum pressure rating of at least 250 psig.
   c. Minimum temperature rating: -10°F.
   d. Maximum temperature rating of at least 170°F for water and glycol solution systems operating 140°F and less.
   e. Maximum temperature rating of at least 250°F for water and glycol solution systems operating above 140°F and up to 180°F.

C. Solder Joints (Copper Pipe):

1. Make up joints with 95% tin and 5% antimony (95-5) solder conforming to ASTM B32 Grade 95TA. Cut copper tubing ends perfectly square and remove all burrs inside and outside. Thoroughly clean sockets of fittings and ends of tubing to remove all oxide, dirt and grease just prior to soldering. Apply flux evenly, but sparingly, to all surfaces to be joined. Heat joints uniformly to proper soldering temperature so solder flows to all mated surfaces. Wipe excess solder, leaving a uniform fillet around cup of fitting.
2. Flux shall be non-acid type conforming to ASTM B813.
3. Solder end valves may be installed directly in the piping system if the entire valve is suitable for use with 470°F melting point solder. Remove composition discs and all seals during soldering if not suitable for 470°F.

D. Welded Joints (Steel Pipe):

1. Welding of all pipe joints, both as to procedures and qualification of welders, shall be in accordance with Section IX, ASME "Boiler & Pressure Vessel Code" unless local codes take precedence.
2. Furnish certificates qualifying each welder to the Owner's Representative prior to start of work.
3. The Owner's Representative reserves the right to require qualifying demonstration, at the Contractor's expense, of any welders assigned to the job.
4. Ends of pipe and fittings to be joined by butt-welding shall be beveled, cleaned to bare metal and internal diameters aligned before tack welding.
5. Single-welded butt joints may be employed with or without the use of backing rings in all sizes. Where backing rings are not used on pumped pressurized systems, the root side of the weld shall either be chipped or ground flush with the piping wall. For services such as vents, overflows, and gravity drains, the backing ring may be eliminated, and the root of the weld need not be chipped or ground. Backing rings shall be of the material being welded.

E. Push-on/Solvent Joints (PVC):

1. Make joints with a two-step process. Use primer conforming to ASTM F656 and solvent cement conforming to ASTM D2564.

F. Polypropylene Socket or Electrofusion:

1. Polypropylene fitting shall be made in accordance with the manufacturer's installation instructions.

G. Heat Fusion Pipe Joining (HDPE Pipe):

1. All HDPE pipe joining shall be heat fused by socket, butt, or saddle (sidewall) fusion in accordance to ASTM D2610, ASTM D2683, and the manufacturer's heat fusion specifications. The operator shall be heat fusion certified and experienced in executing quality fusion joints.

3.10 ACOUSTICAL LAGGING

A. Where indicated on drawings, completely wrap pipe with lagging and seal all joints airtight with tape recommended by the lagging manufacturer to prevent acoustical leakage at joints. Overlap lagging a minimum of 2" at any joint. Overlap lagging 2" at any wall, floor, or structural deck penetration to prevent acoustical leakage.

END OF SECTION 23 21 00

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SECTION 23 21 16 - HYDRONIC SPECIALTIES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Air Vents

B. Automatic Air Vents

C. Makeup Water Accessories

D. Safety Relief Valves

E. Suction Diffusers

F. Balancing Valves

G. Automatic Flow Control Valves

H. Venturi Flow Measurement

I. Combination Piping Packages

J. Expansion Tank

K. Buffer Tanks

L. Sidestream Filters

M. Air Separators

N. Drain Valves and Blowdown Valves

O. Acoustical Lagging

P. Glycol

Q. Glycol Feed System

1.2 QUALITY ASSURANCE

A. Valves: Manufacturer's name and pressure rating marked on valve body. Remanufactured valves are not acceptable.

B. Welding Materials, Procedures, and Operators: Conform to ASME Section 9, ANSI/AWS D1.1, and applicable state labor regulations.

1.3 SUBMITTALS

A. Submit product data under provisions of Section 23 05 00. Include data on pipe materials, fittings, valves, and accessories. Include manufacturers' support spacing requirements for plastic piping.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Store and protect piping to prevent entrance of foreign matter into pipe and to prevent exterior corrosion.

B. Deliver and store valves in shipping containers with labeling in place.

1.5 COORDINATION DRAWINGS

A. Reference Coordination Drawings article in Section 23 05 00 for required hydronic systems electronic CAD drawings to be provided to Coordinating Contractor for inclusion into composite coordination drawings.

PART 2 - PRODUCTS

2.1 AIR VENTS

A. At end of main and other points where large volume of air may be trapped, use 1/4" globe valve, angle type, 125 psi, Crane #89, attached to coupling in top of main, 1/4" discharge pipe turned down with cap.

B. On branch lines and small heating units, use coin-operated air vent equal to B&G #4V, attached to 1/8" coupling in top of pipe. Install air vents on all coils and terminal heating units.

2.2 AUTOMATIC AIR VENTS

A. Low capacity automatic air vent (for bladder tank anti-thermosyphon loops). Maximum operating pressure and temperature of at least 240°F and 125 psi, 1/2" or 3/4" inlet.

1. Manufacturers:

a. Spirotherm - sole source

B. High/low capacity automatic air vent (for air separator connection). Maximum operating pressure and temperature of at least 240°F and 125 psi, 3/4" inlet, 3/8" minimum outlet.

1. Manufacturers:

a. Spirotherm - sole source

2.3 MAKEUP WATER ACCESSORIES

A. Pressure Reducing Valve:

1. For water fill lines to hydronic systems.
2. Removable strainer, field adjustable discharge pressure, brass body, disc and seat, union with 1/2" or 3/4" NPT sweat connection, 125 psig maximum working pressure, 225°F maximum temperature.
3. Manufacturers:

a. Armstrong
b. Bell & Gossett
c. Conbraco
d. Thrush
e. Watts

B. Relief Valve:

1. For water fill lines to hydronic systems.
2. Cast iron or bronze body, 1/2" or 3/4" screwed connections, 125 psig working pressure, 225°F maximum temperature. Minimum 500,000 Btuh capacity at 30 psig. Manual test lever.
3. Manufacturers:

a. Armstrong
b. Bell & Gossett
c. Conbraco
d. Taco
e. Watts

C. Backflow Preventer:

1. Reduced pressure type as scheduled on the drawings.
2. Provide an air gap fitting and piping to drain.
3. If not indicated on the drawings, unit shall be same size as pipe.
4. Field test and tag units per manufacturer's instructions by a certified tester before initial operation.

2.4 SAFETY RELIEF VALVES

A. SRV-1 (Hydronic Heating Systems): Spring-loaded disc type with cast iron or bronze body, bronze or stainless steel disc, side outlet and lifting lever for maximum service of 125 psig at 250°F. For relieving water during pressure fluctuations and in case of control failure. Capacities shall be ASME Section IV certified and labeled.

B. Manufacturers:

1. Kunkle # 537
2. B&G
3. Conbraco
4. McDonnell & Miller
5. Watts

2.5 SUCTION DIFFUSER

A. Furnish and install on base-mounted pumps with inlet size same as pipe size shown on the drawing.

B. In no case shall pressure drop exceed 3.0 psi.

C. Suction diffuser shall consist of angle body with inlet vanes and combination diffuser-strainer-orifice cylinder with 3/16" diameter openings for pump protection, gauge tappings, and blowdown connection. Orifice cylinder, with bronze or stainless steel strainer with free area at least 5 times cross section area of pump suction opening. Furnish adjustable foot to support weight of suction piping. Connect drain valve to blowdown connection. Provide 16 mesh bronze startup strainer. The startup strainer shall be removed after the system has been started, cleaned, and is operating under normal conditions, but before the system is turned over to the Owner. Hang the startup strainer on the piping near the pump after it is removed.

D. Manufacturers:

1. Amtrol
2. Armstrong
3. Bell & Gossett
4. Patterson
5. Taco
6. Wheatley
7. Victaulic

2.6 BALANCING VALVE

A. Rated for 125 psi working pressure and 250°F operating temperature, taps for determining flow with a portable meter, positive shutoff valves for each meter connection, memory feature, tight shutoff, and a permanent pressure drop between 1' and 2' water column at full flow with valve 100% open. Furnish with molded, removable insulation covers.

B. Provide a nomograph to determine flow from meter reading (and valve position on units that sense pressure across a valve). Graph shall extend below the specified minimum flow.

C. Furnish one meter kit equivalent to Bell & Gossett Model RO-5 meeting the following requirements:

1. Carrying case with handle.
2. Pressure gauge with 0-25 feet of head scale with 3.0% full scale accuracy.
3. High and low side hoses with 5 feet length and 250 psig pressure rating, equipped with shutoff valves, vent valves, and probes for insertion into pressure and temperature plugs.

D. Valves in copper piping shall be brass or bronze.

1. Quarter-Turn Ball Valve Style (Brass or Bronze):

a. Manufacturers:

1) Bell & Gossett "Circuit Setter Plus"

2. Quarter-Turn Venturi Style (Brass or Bronze):

a. Manufacturers:

1) Presso "B+"
2) Griswold "Quickset"
3) Gerand "BALVALVE Venturi"
4) HCI "Terminator B"
5) Nexus Valve "UltraXB Orturi"
6) IMI Hydronic Engineering "Accusetter"

3. Multi-Turn Style (Brass or Bronze):

a. Manufacturers:

1) Tour&Anderson (STAD)
2) Armstrong "CBV"
3) Victaulic 786
4) Macon STVL/STV
5) MEPCO MBV
6) Wheatly GS
7) NIBCO 1710

E. Valves in ferrous piping 2" or smaller shall have threaded ends and steel, brass or bronze construction. Option to balancing valves noted above are flow sensors specified in Section 23 09 00 with a specified throttling valve.

1. Quarter-Turn Ball Valve Style (Ferrous Piping ≤ 2"):

a. Manufacturers:

1) Bell & Gossett "Circuit Setter Plus"

2. Quarter-Turn Venturi Style (Ferrous Piping ≤ 2"):

    a. Manufacturers:

        1) Presso "B+"
        2) Gerand "BALVALVE Venturi"
        3) HCI "Terminator B"
        4) Nexus Valve "UltraXB Orturi"
        5) IMI Hydronic Engineering "Accusetter"

3. Multi-Turn Style (Ferrous Piping ≤ 2"):

    a. Manufacturers:

        1) TA Hydronics "786-789"
        2) Armstrong "CBV"
        3) Victaulic 787
        4) Macon STVL/STV
        5) MEPCO MBV
        6) Wheatly GSNIBCO 1710 (T1710L)

F. Balancing valves in ferrous piping over 2 size shall have flanged or grooved ends and steel or cast iron construction. Option to balancing valves noted above are flow sensor specified in Section 23 09 00 with a specified throttling valve.

1. Quarter-Turn Ball Valve Style (Ferrous Piping Greater Than 2"):

    a. Manufacturers:

        1) B&G "Circuit Setter"

2. Quarter-Turn Venturi Style (Ferrous Piping Greater Than 2"):

    a. Manufacturers:

        1) Presso "B+"
        2) Taco "Accu-flo"
        3) HCI "Terminator G"
        4) Nexus Valve "Nextrol NXFB"
        5) IMI Hydronic Engineering "Accusetter"

3. Multi-Turn Style (Ferrous Piping Greater Than 2"):

    a. Manufacturers:

        1) Armstrong "CVB-II"
        2) Tour&Anderson (STAF, STAG)
        3) Victaulic 788/789
        4) Macon STVA
        5) MEPCO MBV
        6) NIBCO 737

G. Balancing valves in ferrous piping over 2" size shall consist of flow sensors as specified in Section 23 09 00 combined with specified throttling valves.

H. Manufacturer shall size balancing valves for the scheduled flow rate. Flow rate shall be measurable on manufacturer's standard meters.

2.7 AUTOMATIC FLOW CONTROL VALVES (AUTOMATIC BALANCING VALVES)

A. The GPM for the automatic flow control valves shall be factory set and shall automatically limit the rate of flow to within ± 10% of the specified GPM over at least 95 percent of the control range.

B. Pump Head Requirements: The permanent pressure loss added to the pump head shall not exceed 7 feet .

C. Each valve shall have two P/T ports.

D. Five-year product warranty and first year cartridge exchange, up to 10 percent.

E. The internal wear surfaces of the valve cartridge shall be stainless steel or polyphenylsulfone orifice with an elastomeric diaphragm.

F. The internal flow cartridge shall be permanently marked with the GPM and spring range.

G. Valve body shall be brass on all valves 2" and under and ductile iron on all valves 2-1/2" and larger.

H. All valves shall be factory leak tested at 100 psi air under water.

I. A differential pressure test kit shall be supplied to verify flow and measure over-heading. The kit shall consist of a 4-1/2" diaphragm gauge equipped with 10 foot hoses and P/T adapters all housed in a vinyl case. Calibration shall be 0-35 PSID for 2-32 PSI spring range or 0-65 PSID for 5-60 PSI range.

J. Manufacturers:

1. Griswold
2. Autoflow
3. Versa Flow
4. Nexus
5. B&G
6. Victaulic
7. Hays Fluid Controls

K. Complete integral piping package, which integrates shutoff valves, automatic flow control valves, vents, strainers and drains, is acceptable.

2.8 VENTURI FLOW MEASUREMENT

A. Static Low loss Venturi: Flanged or grooved end, 400 psig at 250 deg F working pressure; ANSI 150 pressure class; carbon steel body and insert; P/T ports for external gauge connection; ± 3% accuracy. Size venturi to match pipe (not pump outlet) size, but reduce size by not more than one (1) if needed to provide a minimum of 20" w.c. differential pressure across the flow measuring taps at scheduled design flow rate. In no instance shall pressure drop exceed 60" w.c. at scheduled design flow rate.

B. Manufacturers:

1. IMI Flow Design
2. Hayes Fluid Controls
3. Tunstall/Macon
4. Bell and Gossett

2.9 COMBINATION PIPING PACKAGES

A. Combination piping packages are allowed at unitary equipment only (1" pipe size and smaller) in lieu of individual components specified for hydronic coils and devices containing hydronic coils. Configuration of combination pieces shall match layouts on the drawings. Each component of the combination piping packages shall meet these specifications for the individual components being combined. Coil connections shall be rigid. Combination piping packages shall include:

1. Shutoff valves
2. Wye strainers, with 1/4 turn strainer blowdown valves with hose thread and cap
3. Manual balancing valves with memory stop. Automatic flow control devices are not allowed.
4. Test plugs
5. Manual air vents
6. Unions

B. Manufacturers:

1. FDI Flowset
2. Griswold
3. Hays Fluid Controls
4. HCI Terminator
5. Nexus Coil Pak
6. NIBCO, Victaulic

2.10 EXPANSION TANK

A. Compression Type:

1. Tank shall be welded steel, guaranteed air-tight and leakproof, ASME construction, stamped for 125 psig working pressure.
2. Furnish with air control fitting and drain valve.
3. 375°F maximum operating temperature.
4. Furnish bronze 3/4" gauge glass, tested for at least 200 psi, hand wheel automatic valves with rubber washer for glass and 1/4" drain cock.
5. Manufacturers:

   a. Bell & Gossett
   b. Adamson
   c. Taco
   d. Armstrong
   e. Ace Buehler
   f. Wessels
   g. Wheatley
   h. Amtrol
   i. Patterson
   j. Grundfos

B. Bladder Type:

1. Tank shall be welded steel, ASME construction and stamped.
2. Tank shall be complete with heavy-duty replaceable butyl bladder, charging valve, lifting ring, drain tapping, and system connection.
3. 125 psig working pressure and 240°F maximum operating temperature.
4. Manufacturers:

   a. Thrush
   b. Taco
   c. Bell & Gossett
   d. Armstrong

e. Watts
f. Wessels
g. Wheatley
h. Amtrol
i. Patterson
j. Grundfos

2.11 BYPASS/SIDESTREAM FILTER

A. Cartridge filtration system rated for up to 50 gpm.

B. Filter vessel shall be 304 stainless steel and suitable for use up to 150 psi maximum operating pressure.

C. Vessel shall be equipped with an automatic air vent, manual air vent, and pressure gauge.

D. Filter shall be capable of removing 90% of all particles 5 microns and larger with each pass through the media.

E. Filter cartridge shall have a PVC core to prevent cartridge from collapse.

F. Filtration system shall be suitable for use up to 200°F.

G. System shall be provided with close coupled centrifugal pump with strainer capable of providing flow as scheduled on drawings.

H. System shall be provided with control panel with disconnect, transformer to provide 120V 24V control power, overload and short circuit protection, dry contacts for connection to the building automation system, and single-point electrical supply connection.

I. Filtration system components shall be pre-piped and skid mounted as a single unit.

J. Mechanical Contractor shall provide and install shutoff valves on both up and downstream sides of filtration system, a check valve on suction side of pump between shutoff valve and pump, and drain piping to nearest trench drain.

K. Manufacturers:

1. PEP
2. Lenntech Filters
3. Parker Hannifin
4. United Filtration Systems
5. Lakos

2.12 COALESCING TYPE COMBINATION AIR ELIMINATOR AND DIRT SEPARATOR

A. Coalescing type air eliminator and dirt separator shall be fabricated from steel and ASME constructed and certified for 125 psi working pressure rated for 150 psig working pressure. Designed and constructed in accordance with ASME with ASME stamp, with two equal chambers above and below the inlet / outlet nozzles. Flanges to be Class 150, raised face, weld neck. and 270°F operating temperature. Units 2-1/2 inches and smaller shall have threaded connections. Units 3 inches and larger shall have flanged connections.

B. Unit shall include internally structured coalescing media elements uniformly filling the entire vessel to suppress turbulence and provide air elimination efficiency of at least 99.5% free and entrained air, and 99.6% dissolved air at the installed location. Dirt separation efficiency shall be a minimum of 80% of all particles 30 micron and larger within 100 passes. Units capable of 5 micron dirt removal.

C. Air elimination and dirt separation shall be by coalescing action by copper tubes with continuous wound, permanently attached copper wire and followed by a separate continuous wound permanently affixed copper wire.

D. Provide unit with factory mounted air vent at the top of the air elimination chamber.

E. Provide brass flushing cock on the separator side to facilitate system fast-fill and to blow down impurities from the water surface within the separator.

F. Provide factory-mounted blowdown valve on the unit bottom to allow for draining and cleaning. Coalescing separators shall be equipped with removable cover to allow for removal, inspection. and cleaning of the internal coalescing media.

G. Units shall be painted. Units with a primer finish are not acceptable.

H. Warranty: Three-year.

I. Coalescing separator shall be as sized on the construction drawings, but in no case shall it have less than line size connections nor shall entering velocity exceed 10 feet per second. Pressure drop shall not exceed 5psi at design flow. Include on submittal the pressure drop of each unit at its design flow rate.

J. Manufacturers:

1. Spirotherm - sole source

2.13 DRAIN VALVES AND BLOWDOWN VALVES

A. Drain valve and blowdown valve shall mean a shutoff valve as specified for the intended service with added 3/4" male hose thread outlet, cap, and retaining chain.

2.14 CONNECTIONS BETWEEN DISSIMILAR METALS

A. Connections between dissimilar metals shall be insulating dielectric types that provide a water gap between the connected metals, and that either allow no metal path for electron transfer or that provide a wide water gap lined with a non-conductive material to impede electron transfer through the water path.

B. Joints shall be rated for the temperature, pressure, and other characteristics of the service in which they are used, including testing procedure.

C. Aluminum, iron, steel, brass, copper, bronze, galvanized steel, and stainless steel are commonly used and require isolation from each other with the following exceptions:

1. Iron and steel connected to each other.
2. Brass, copper, and bronze connected to each other.
3. Brass or bronze valves and specialties connected in closed systems with steel, iron, or stainless steel on both sides of the brass or bronze valves and specialties. Where two or more brass or bronze items occur together, they shall be connected with brass nipples. Brass or bronze valves and specialties cannot be used as a dielectric separation between pipe materials.

D. Dielectric protection is required at connections to equipment of a material different than the piping.

E. Screwed Joints (acceptable up to 2" size):

1. Dielectric waterway rated for 300 psi CWP and 225°F.

2. Manufacturers:

   a. Elster Group ClearFlow fittings
   b. Victaulic Series 647
   c. Grinnell Series 407
   d. Matco-Norca

F. Flanged Joints (any size):

1. Use 1/8" minimum thickness, non-conductive, full-face gaskets.
2. Employ one-piece molded sleeve-washer combinations to break the electrical path through the bolts.
3. Sleeve-washers are required on one side only, with sleeves minimum 1/32" thick and washers minimum 1/8" thick.
4. Install steel washers on both sides of flanges to prevent damage to the sleeve-washer.
5. Separate sleeves and washers may be used only if the sleeves are manufactured to exact lengths and installed carefully so the sleeves must extend partially past each steel washer when tightened.
6. Manufacturers:

   a. EPCO
   b. Central Plastics
   c. Pipeline Seal and Insulator
   d. F.H. Maloney
   e. Calpico

2.15 ETHYLENE GLYCOL

A. Fill glycol systems with a mixture of water and ethylene glycol based low temperature industrial heat transfer fluid with an expected life of at least 12 years in normal use. *Water shall meet the glycol manufacturer's recommendations (generally less than 25ppm chloride, sulfite, and hardness). Distilled, deionized, or reverse osmosis water is acceptable, as are pre-diluted solutions from the manufacturer. Solution shall contain a fluorescent dye to facilitate leak detection.*

B. Fluid suitable for use from -60°F to 250°F.

C. Glycol shall *pass ASTM D1384 (less than 0.5 mils annual penetration of all system metals).* Glycol supplier shall provide a certificate of assurance.

D. A 50% solution by weight shall depress the freezing point to at least -29°F. At 40°F the solution shall have viscosity of not over 6 centipoise, thermal conductivity of at least 0.21 Btu/hr*ft*°F, specific heat of at least 0.79 Btu/lbm*°F, and specific gravity of at least 1.08.

E. The glycol manufacturer shall analyze the fluid biannually to ensure the corrosion protection properties continue to meet industry standards. This shall be at no cost to the Owner. No chemical additions shall be made to the glycol solution until an analysis is completed.

F. Automotive glycol containing sodium silicate is not acceptable.

G. Manufacturers:

1. Dow Chemical "Dowtherm SR-1"
2. Interstate Chemical "Intercool NFE"
3. Houghton Chemical "Wintrex"
4. Texaco

2.16 GLYCOL FEED SYSTEM

A. Package system complete with storage tank, pump(s) and controls with audio and visual alarm, designed to add glycol solution to a closed loop water system. System shall automatically maintain pressure in the piping system.

B. Provide cut-off and alarm to stop pump in case of low level or high pressure. Provide dry contact for alarm point to the DDC.

C. Complete with polyethylene storage tank and lid. Mount on floor above pumping assembly in a steel frame with legs. Lid shall be removable for filling and provide means for system relief valve outlet to be piped back to tank without removal of piping from relief valve or automatic air vent.

D. Pumping system shall consist of a pump, starter, pressure tank with pressure control, pressure reducing valve, shutoff valve and pressure gauge. Refer to schedule for pump requirements.

E. Manufacturers:

1. Wessels GMP
2. Advantage Controls AGF
3. B&G GMU
4. Patterson
5. Grundfos

PART 3 - EXECUTION

3.1 INSTALLATION

A. Valves/Fittings and Accessories:

1. Where a manual balance valve is shown to be installed in series with a service (isolation) valve, separate balance and service (isolation) valves shall be installed.
2. Install balancing valves with the manufacturer's recommended straight upstream and downstream diameters of pipe.

Product	Upstream Diameters	Downstream Diameters
Griswald "Quickset"	0	0
Fluid Design "Accusetter"	0 up to 2" size	0
	5 for larger sizes	
Presso "B+"	5	2
Taco "Accu-flo"	10	5
TA Hydronics 786-789	5 after fittings	2
	10 after pumps	
Bell & Gossett "Circuit Setter Plus"	3	1
Bell & Gossett "Circuit Setter"	3 up to 4" size	1 up to 4" size
	5 above 4" size	2 above 4" size
Armstrong "CVB" and "CVB-II"	10	5
Gerand "BALVALVE Venturi"	5	2
NIBCO 1710/737	5	3

3. Prepare accessories for finish painting.
4. Install accessories with stems upright or horizontal, not inverted, except install manual quarter turn valves in radiation cabinets and all butterfly valves with stems horizontal.
5. Provide shutoff valves and flanges or unions at all connections to equipment, traps, and items that require servicing.
6. Provide flanges or unions at all final connections to equipment, traps and valves.
7. Arrange piping and piping connections so equipment may be serviced or totally removed without disturbing piping beyond final connections and associated shutoff valves.

3.2 ACOUSTICAL LAGGING

A. Where indicated on drawings, completely wrap pipe with lagging and seal all joints airtight with tape recommended by the lagging manufacturer to prevent acoustical leakage at joints. Overlap lagging a minimum of 2" at any joint. Overlap lagging 2" at any wall, floor, or structural deck penetration to prevent acoustical leakage.

END OF SECTION 23 21 16

SECTION 23 21 23 - HVAC PUMPS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. All pumps except where integral with a manufactured piece of equipment.

B. Pump controls where self-contained.

1.2 SUBMITTALS

A. Submit shop drawings under provisions of Section 23 05 00.

B. Submit certified pump performance curves with pump and system operating point plotted. Include NPSH curve when applicable.

C. Submit motor data indicating compliance with Section 23 05 13.

D. Submit certification that pumps, accessories, and components will withstand seismic forces defined in Section 23 05 50. Include the following:

1. Basis for Certification: Indicate whether certification is based on actual test of assembled components or on calculation.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

PART 2 - PRODUCTS

2.1 PUMPS - GENERAL

A. Statically and dynamically balance rotating parts.

B. Construction shall permit complete servicing without breaking piping or motor connections.

C. Pumps shall operate at 1750 rpm unless specified otherwise.

D. Pump connections shall be flanged, whenever available.

E. Heating pumps shall be suitable for 225°F water.

F. Motors shall comply with Section 23 05 13.

G. Pump impellers shall not have smaller diameters than those scheduled. The inlet and discharge pipe sizes shall also meet or exceed the scheduled pump.

H. Pumps specified in this section operating in clean water with a flow greater than 25 GPM and less than 459 feet head shall have a maximum Pump Energy Index (PEI) as scheduled on the drawings. In no case shall the PEI exceed 1.0.

2.2 SPLIT CASE BASE MOUNTED PUMPS

A. Type: Centrifugal, single stage, double suction, horizontal or vertical split case, direct connected.

B. Casing: Cast iron, rated for greater of 150 psi or 1.50 times actual working discharge pressure, suction and discharge flanges with gauge ports, soldered case rings, and cast bearing supports integral with bottom section for bearing alignment.

C. Impeller: Bronze, fully enclosed, keyed to shaft.

D. Shaft: Carbon steel with O-ring seals and bronze or stainless steel shaft sleeves.

E. Bearings: Grease lubricated roller or ball bearings with grease fittings. Bearings shall be L-10 rated for 100,000 hours. If pump will be insulated, grease fittings shall be extended 3" with rigid pipe to clear the insulation.

F. Drive: Flexible coupling with OSHA approved guard.

G. Seals: Mechanical type with internal flushing rated for -20 to 225°F and comprised of Buna elastomer, carbon primary ring, and ceramic stationary ring.

H. Baseplate: Reinforced heavy steel.

I. Manufacturers:

1. Grundfos/Peerless/PACO

2.3 BASE MOUNTED END SUCTION PUMPS

A. Type: Centrifugal, single stage.

B. Casing: Cast iron, single suction, rated for greater of 150 psi or 1.25 times actual working discharge pressure, flanged suction and discharge with gauge ports.

C. Impeller: Bronze, fully enclosed, keyed to shaft.

D. Shaft: High grade alloy steel with copper, bronze or stainless steel shaft sleeves.

E. Bearings: Grease lubricated roller or ball bearings with grease fittings. If pump will be insulated, grease fittings shall be extended 3" with rigid pipe to clear the insulation.

F. Drive: Flexible coupling with OSHA-approved guard.

G. Seals: Mechanical type with internal flushing rated for -20 to 225°F with Buna elastomer, carbon primary ring, and ceramic stationary ring.

H. Baseplate: Heat treated cast iron or reinforced heavy steel.

I. Manufacturers:

1. Grundfos/Peerless/PACO

2.4 IN-LINE PUMP

A. Type: Centrifugal, single stage, close coupled in-line, back pullout design, suitable for horizontal or vertical operation.

B. Casing: Cast iron, rated for greater of 125 psi or 1.5 times actual working discharge pressure, flanged suction and discharge with gauge ports.

C. Impeller: Bronze or stainless steel, fully enclosed, dynamically balanced, keyed to shaft and secured with locknut.

D. Shaft: Steel or stainless steel.

E. Seals: Mechanical type with internal flushing rated for -20 to 225°F and comprised of Buna elastomer, carbon primary ring, and ceramic stationary ring.

F. Seals: Mechanical type rated for -20 to 250°F with EPR or EPT bellows and seat gasket, carbon primary ring, and silicon-carbide stationary ring.

G. Manufacturers:

1. Grundfos/Peerless/PACO

PART 3 - EXECUTION

3.1 INSTALLATION

A. General Installation Requirements:

1. Install all products per manufacturer's recommendations.
2. Support piping adjacent to pumps so that no weight is carried by pump casings. Provide supports under elbows on 4" and larger pump suction and discharge pipes. Allow a minimum of 18" clearance for removal of suction diffuser.
3. Ensure pumps operate at specified fluid temperatures without vapor binding or cavitation, are non-overloading in parallel or individual operation, and operate within 25% of midpoint of published maximum efficiency curve.
4. Install on vibration isolators as scheduled on drawings.

B. In-Line Pumps:

1. Support in-line pumps individually so there is no strain on the piping. Install with a minimum of five diameters of straight pipe on pump suction and discharge.
2. Pump orientation shall be in accordance with the manufacturer’s recommendations.

C. Base-Mounted Pumps:

1. Base-mounted pump shall be aligned in accordance with the pump manufacturer’s recommendations. A factory-trained representative shall laser align the pump to meet the manufacturer’s requirements and tolerances. An alignment report shall be provided as part of the project closeout documents.
2. Unless otherwise shown on the drawings, mount all base mounted pumps on 4" high concrete pads and anchor frames to pads with cast-in-place anchors.
3. All base-mounted pumps shall be grouted-in. Follow manufacturer's instructions for grouting.

END OF SECTION 23 21 23

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SECTION 23 22 00 - STEAM AND STEAM CONDENSATE PIPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Pipe and Pipe Fittings.

B. Valves.

C. Steam Piping System.

D. Condensate Piping System.

E. Acoustical Lagging.

1.2 QUALITY ASSURANCE

A. Valves: Manufacturer's name and pressure rating marked on valve body. Remanufactured valves are not acceptable.

B. Welding Materials and Procedures: Conform to ANSI/ASME SEC 9.

1.3 SUBMITTALS

A. Submit product data under provisions of Section 23 05 00. Include data on pipe fittings, valves and accessories.

B. Include certification of compliance with ANSI/AWS D1.1 for all welders.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Store and protect piping to prevent corrosion and entrance of foreign matter.

B. Deliver and store valves in shipping containers with labeling in place.

1.5 REGULATORY REQUIREMENTS

A. Conform to ANSI/ASME B31.9 for the following pipe systems:

1. Boiler external pipe systems that operate up to 15 psi.
2. Non-boiler external pipe systems that operate up to 150 psi.

B. Conform to ANSI/ASME B31.1 for boiler external pipe systems that operate above 15 psi.

C. Refer to ANSI/ASME B31.1 and ANSI/ASME B31.9 for "boiler external piping" and "non-boiler external piping" definitions.

1.6 COORDINATION DRAWINGS

A. Reference Coordination Drawings article in Section 23 05 00 for required steam and steam condensate piping systems electronic CAD drawings to be provided to Coordinating Contractor for inclusion into composite coordination drawings.

PART 2 - PRODUCTS

2.1 STEEL PIPING (0 TO 125 PSIG)

A. Steel Pipe; 0 to 125psig; Standard Weight; Threaded Joints:

1. Design Pressure: 125 psig. Maximum Design Temperature: 353°F.
2. Pipe: Standard weight black steel, threaded and coupled, ASTM A53.
3. Joints: Screwed.
4. Fittings: 125 psi S - 175 psi. WOG, cast iron, ASTM A126, ANSI B16.4.
5. Unions: 250 psi S - 500 psi. WOG, black malleable iron, ground joint with brass seat.

B. Steel Pipe; 0 to 125psig; Standard Weight; Flanged Joints or Welded Joints:

1. Design Pressure: 125 psig. Maximum Design Temperature: 353°F.
2. Pipe: Standard weight black steel, beveled ends, ASTM A53.
3. Joints: Butt welded or flanged.
4. Fittings: Standard weight seamless steel, butt welded type, ASTM A234, Grade WPB, ANSI B16.9.
5. Flanges: 150 lb. forged steel, welding neck or slip-on, ASTM A181, Grade I, ANSI B16.5. Flange face seal weld (backweld) is required for slip-on flanges.

C. Steel Pipe; 0 to 125psig; Extra Strong; Threaded Joints:

1. Design Pressure: 125 psig. Maximum Design Temperature: 353°F.
2. Pipe: Extra strong black steel, threaded and coupled, ASTM A53.
3. Joints: Screwed.
4. Fittings: 125 psi S - 175 psi WOG, cast iron, ASTM A126, ANSI B16.4.
5. Unions: 250 psi S - 500 psi WOG, black malleable iron, ground joint with brass seat.

D. Steel Pipe; 0 to 125psig; Extra Strong; Flanged Joints or Welded Joints:

1. Design Pressure: 125 psig. Maximum Design Temperature: 353°F.
2. Pipe: Extra strong black steel, beveled ends, ASTM A53.
3. Joints: Butt welded or flanged.
4. Fittings: Extra strong seamless steel, butt weld type, ASTM A234, Grade WPB, ANSI B16.9.
5. Flanges: 150 lb. forged steel, welding neck or slip-on, ASTM A181, Grade I, ANSI B16.5. Welding neck type shall be used wherever possible and shall have bore to match pipe. Flange face seal weld (backweld) is required for slip-on flanges.

2.2 VALVES

A. Boiler/Shutoff Valves:

1. Gate Valves:

   a. GA-2 (0 to 125 psig): 2-1/2" thru 12", 125 psi S @ 353°F, 200 psi WOG @ 150°F, flanged, Cast Steel Body, bronze mounted, OS&Y. Crane 47 , Hammond, Stockham, Walworth, Milwaukee #F2885, Watts #F-503, NIBCO F-617-O.

b. GA-4 (126 to 250 psig): 2-1/2" thru 12", 250 psi S @ 405°F, 500 psi WOG @ 150°F, flanged, iron body, bronze mounted, OS&Y. Crane #7-1/2E, Hammond, Stockham, Walworth #W786F, Milwaukee #F2894, Watts, NIBCO F-667-O.

B. Shutoff Valves:

1. BA-1: 3" and under, 125 psi saturated steam, 600 psi WOG, full port, screwed ends , Navy bronze body of a copper alloy containing less than 15% zinc, stainless steel ball and trim, Teflon seats and seals. Apollo #77C-140, Stockham #S-206 BR1-R, Milwaukee #BA-400, Watts, Nibco #585-70-66, National Utilities Co., RUB.
2. BA-1A (0 to 125 psig): 2-1/2" and 3", 150 psi saturated steam, 275 psi WOG ANSI Class, 150 psi standard port, carbon steel body stainless steel ball and trim, Teflon seats and seals. Apollo #88A-100, Nibco #F510-CS/66, Milwaukee #F90.

C. Throttling/Shutoff Valves:

1. Globe Valves (0 to 125 psig):

a. GL-1 (0 to 125 psig): 2" and under, 125 psi saturated steam, 300 psi WOG, screwed, bronze. Crane #7TF, Stockham #B22T, Walworth #3095, Milwaukee #590, Hammond #IB413, Watts #B-4010-T, NIBCO T-235-Y.
b. GL-2 (0 to 125 psig): 2-1/2" thru 10", 125 psi S @ 353°F, 200 psi WOG @ 150°F, flanged, iron body, bronze mounted. Crane #351, Hammond #IR116, Stockham #G-512, Walworth #8906F, Milwaukee #F2981, Watts #F-501, NIBCO F-718-B.
c. GL-4 (126 to 250 psig): 2-1/2" thru 8", 300 psi S @ 800°F, 740 psi WOG @ 100°F, flanged, cast steel body. Crane #151XU, Stockham #30GPF, Walworth #5281F.
d. GL-8 (126 to 250 psig): 2" and under, 800# steam, socket weld, forged steel, OS&Y, bolted bonnet. Vogt Valves SW10103.

2.3 CHECK VALVES

A. CK-1 (0 to 125 psig): 2" and under, 125 psi S @ 353°F, 200 psi WOG @ 150°F, screwed, bronze, horizontal swing. Crane #37, Hammond #IB904, Stockham #B319, Walworth #3406, Milwaukee #509, Watts #B-5000, NIBCO T-413-Y.

B. CK-6 (0 to 125 psig): 2-1/2" thru 12", 125 psi S @ 353°F, 200 psi WOG @ 150°F, flanged, all iron, horizontal swing. Crane #373-1/2, Hammond #IR1126, Stockham #G933, Walworth #8928-1/2F, Milwaukee #F2971, Watts #F-511-R, NIBCO F-918-Ng.

C. CK-3 (126 to 250 psig): 2-1/2" thru 12", 250 psi S @ 405°F, 500 psi WOG @ 150°F, flanged, iron body, bronze mounted, horizontal swing. Crane #39E, Hammond #IR322, Stockham #F947, Walworth #8970F, Milwaukee #F2970, Watts #F-569, NIBCO F-968-B.

D. CK-9 (126 to 250 psig): 2" and under, 800 psi S, socket weld, forged steel, lift type with bolted cover. Lunkenheimer #2317W.

2.4 STRAINERS

A. ST-1 (0 to 125 psig): Cast iron body, screwed ends, screwed cover, 250# steam @ 406°F, 400# WOG @ 150°F. Armstrong #CA1SC, Metraflex #TS, Mueller Steam Specialty Co. #11M, Sarco #IT, Watts #77S, NIBCO T-751. Bronze body strainer 125# may be used as contractor option.

B. ST-2 (0 to 125 psig): Cast iron body, 125 lb. flanged ends, bolted cover, 125 psi S @ 353°F, 175 psi WOG @ 150°F. Armstrong #A1FL, Metraflex #TF, Mueller Steam Specialty Co.#758, Sarco #CI-125, Watts #77F, NIBCO F-721.

C. ST-5 (126 to 250 psig): Cast steel body, socket weld ends, screwed cover, 600# steam @ 850°F, 1440# WOG @ 150°F. Armstrong #B1SW, Mueller Steam Specialty Co. #862, Sarco #CT.

D. ST-6 (126 to 250 psig): Cast steel body, 300# flanged ends, bolted cover, 300# steam, 720# WOG. Armstrong #B1FL, Mueller Steam Specialty Co. #762, Sarco #1738.

E. Unless otherwise indicated, strainers shall have stainless steel screens with perforations as follows:

1. Steam All Sizes: 1/32"
2. Condensate All Sizes: 3/64"

F. Furnish pipe nipple with gate valve and threaded cap to blow down all strainer screens.

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. Remove all scale, rust, dirt, oils, stickers and thoroughly clean exterior of all bare metal exposed piping, hangers, and accessories in preparation to be painted.

D. Make connections to equipment with flanges or unions.

E. After completion, fill, clean, and treat systems.

3.2 PIPING SCHEDULE

A. Steam (0 to 125 psig):

1. Steel Pipe; 0 to 125 psig; Standard Weight; Threaded Joints: 2" and Under
2. Steel Pipe; 0 to 125 psig; Standard Weight; Flanged Joints or Welded Joints: 2-1/2" and Over
3. Boiler Shutoff Valves: GA-2
4. Shutoff Valves: GA-2, BA-1, BA-1A
5. Throttling: GL-1, GL-2
6. Check Valves: CK-1, CK-6
7. Strainers: ST-1, ST-2

B. Condensate Piping (0 to 125 psig):

1. Steel Pipe; 0 to 125 psig; Extra Strong; Threaded Joints: 2" and Under
2. Steel Pipe; 0 to 125 psig; Extra Strong; Flanged Joints or Welded Joints: 2-1/2" and Over
3. Boiler Shutoff Valves: GA-2
4. Shutoff Valves: GA-2, BA-1, BA-1A
5. Throttling: GL-1, GL-2
6. Check Valves: CK-1, CK-6
7. Strainers: ST-1, ST-2

3.3 TESTING PIPING

A. Complete all testing of pipes underground, or in chases and walls, before piping is concealed.

B. Complete all testing before insulation is applied, or if insulation is applied before the pipe is tested and a leak develops which ruins the insulation, the pipe installing contractor shall arrange and pay for replacing the damaged insulation.

C. Test piping with water at 150% of the maximum operating pressure.

D. Hold pressure for at least two hours.

E. Test to be witnessed by the Architect/Engineer or their representative, if requested by the Architect/Engineer.

3.4 CLEANING PIPING

A. Assembly:

1. Prior to assembly of pipe and piping components, all loose dirt, scale, oil and other foreign matter on internal or external surfaces shall be removed by means consistent with good piping practice subject to the approval of the Architect/Engineer's representative. Chips and burrs from machinery or thread cutting operation shall be blown out of pipe before assembly. Cutting oil shall be wiped from internal and external surfaces.
2. During fabrication and assembly, remove slag and weld spatter from both internal and external pipe joints by peening, chipping and wire brushing.
3. Notify the Architect/Engineer's representative prior to starting any post erection cleaning operation in sufficient time to allow witnessing the operation. Consult with and obtain approval from the Architect/Engineer's representative regarding specific procedures and scheduling. Arrange for proper disposal of cleaning and flushing fluids.
4. When the system is started up for the first time, discharge the condensate to drain per the boiler manufacturer's recommendations or for 24 hours, whichever is more restrictive. Add domestic cold water to the drain at a sufficient rate to reduce the condensate temperature to a maximum of 140°F.

3.5 INSTALLATION

A. General Installation Requirements:

1. Route piping in orderly manner, plumb and parallel to building structure, and maintain gradient.
2. Install piping to conserve building space and not interfere with use of space, other work, or equipment.
3. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
4. Slope steam piping 0.25" in 10 feet in direction of flow. Use eccentric reducers to maintain bottom of pipe level.
5. Slope steam condensate piping 0.5" in 10 feet.
6. Where pipe supports are welded to structural building framing, scrape, brush clean, and apply zinc rich primer to welds.

B. Installation Requirements in Electrical Rooms:

1. Do not install piping or other equipment above electrical switchboards or panelboards. This includes a dedicated space extending 25 feet from the floor to the structural ceiling with width and depth equal to the equipment.

C. Valves/Fittings and Accessories:

1. Provide clearance for installation of insulation and access to valves and fittings.
2. Provide access doors where valves and fittings are not exposed.
3. Provide drip trap assembly at low points and before control valves and pressure reducing valves.
4. Provide loop vents over trapped sections.
5. Prepare pipe, fittings, supports, and accessories for finish painting.

6. Provide drip legs as shown on the drawings, at low points, traps, and the base of all risers in steam, and condensate pipes. Unless otherwise shown, drip legs shall be full pipe size on pipes through 4" and at least 4", but not less than half line size over 4". Drip legs shall be 12" minimum length, with a reducer and a 3/4"shutoff valve.
7. Install valves with stems upright or horizontal, not inverted.
8. Provide shutoff valves in supply and return to all equipment.
9. Install strainers in steam piping with the "wye" of the strainer to the side of the pipe in the horizontal plane to avoid pooling of condensate.

3.6 PIPE ERECTION AND LAYING

A. Carefully inspect all pipe, fittings, valves, equipment and accessories before installation. Any items that are unsuitable, cracked or otherwise defective shall be rejected and removed from the job immediately.

B. All pipe, fittings, valves, equipment and accessories shall have factory applied identification sufficient to determine conformance with specified requirements.

C. Exercise care at every stage of storage, handling, laying and erecting to prevent entry of foreign matter into piping, fittings, valves, equipment and accessories. Do not erect or install any item that is not clean.

D. During construction, until system is fully operational, keep all openings in piping and equipment closed except when actual work is being performed on that item of system. Use plugs, caps, blind flanges or other items designed for this purpose.

E. Run pipe straight and true, parallel to building lines with minimum use of offsets and couplings. Provide only offsets required for needed headroom or clearance and to provide needed flexibility in piping.

F. Change direction of pipes only with fittings or pipe bends. Change size only with fittings. Do not use miter fittings, face or flush bushings, or street elbows. All fittings shall be long radius type, unless otherwise noted.

G. Provide flanges or unions at all connections to equipment traps and valves to facilitate dismantling.

H. Arrange piping and connections so equipment served may be serviced or totally removed without disturbing piping beyond final connections and associated shutoff valves.

I. Use full and double lengths of pipe wherever possible.

J. Unless otherwise indicated, install all inlet and outlet piping, including shutoff valves and strainers, to coils, pumps and other equipment at line size with reduction in size made only at control valve, pump, or trap.

K. Cut all pipe to exact measurement and install without springing or forcing.

L. Avoid creating, even temporarily, undue loads, forces or strains on valves, equipment or building elements with piping connections or supports.

M. Unless otherwise indicated, branch takeoffs shall be from top of mains or headers at either a 45° or 90° angle from the horizontal plane for steam pipes.

N. Branch takeoffs shall be from the top, side (if branch is two sizes smaller than main), or any angle from the horizontal plane to the top of piping for liquids.

3.7 BRANCH CONNECTIONS

A. Make branch connections with standard tee or cross fittings of the type required for the service unless otherwise indicated.

B. Reducers are generally not shown. Where pipe sizes change at tee, the tee shall be the size of the largest pipe shown connecting to it.

C. Branch connections from mains may be cut into black steel pipe using forged weld-on fittings:

1. Steam.
2. Condensate.
3. Boiler Feedwater.

D. Use of forged weld-on fittings is further limited as follows:

1. Must have at least same pressure rating as the main.
2. Header or main must be 2-1/2" or over.
3. Branch pipe is at least two sizes under main size.

3.8 JOINING OF PIPE

A. Threaded Joints (Steel Pipe):

1. Screw threads shall conform to ANSI B2.1 "Pipe Threads".
2. Ream pipe ends and remove all burrs and chips formed in cutting and threading.
3. Protect plated pipe and valve bodies from wrench marks.
4. Apply high temperature, anti-seize thread lubricant to male threads.

B. Flanged Joints (Steel Pipe):

1. Steel flanges shall conform to ANSI B16.5 "Steel Pipe Flanges and Flanged Fittings". Cast iron flanges shall conform to ANSI B16.1 "Cast Iron Flanged and Flanged Fittings". Steel flanges shall be raised face except when bolted to flat face cast iron flange.
2. Bolting for services up to 399°Fshall be ASTM A307, Grade B bolts and heavy hexagonal nuts. Bolting for services from 400°Fto 790°Fshall be ASTM A193, Grade B-7 with Grade 24 hexagonal nuts. Bolts and nuts shall conform to ANSI B18.2.1 "Square and Hex Bolts" or B18.2.2 "Square and Hex Nuts".
3. Set flange bolts beyond finger tightness with an indicating torque wrench to insure equal tension in all bolts. Tighten bolts so those directly opposite are torqued in sequence.
4. Gaskets for flat face flanges shall be full face type. Gaskets for raised faced flanges shall conform to requirements for "Group I Gaskets" in ANSI B16.5. Unless otherwise specified gaskets shall meet the following requirements:

   a. Gasket material and thickness approved by manufacturer for intended service, chemical compatibility, pipe system test pressure, and operating temperature range.
   b. Gaskets used in piping systems for saturated steam service shall be approved by manufacturer for use in saturated steam applications up to and including 150 psig.
   c. Gaskets used for superheated steam applications and for saturated steam systems with operating pressures greater than 150 psig saturated steam shall be of the spiral wound "chevron" metallic type with flexible graphite filler by the following manufacturers:

      1) Flexitallic (LS Style CG)
      2) TEADIT (Style 913)
      3) Garlock (Flexseal Style RW)
      4) Lamons (SpiraSeal Style WR)
      5) Leader (Style LG-13)

   d. Gaskets used for steam condensate service including, but not limited to, condensate return, boiler feedwater, and condensate transfer piping systems shall meet the following requirements:

      1) Maximum pressure rating of at least 2,000 psig.
      2) Maximum continuous temperature rating of at least 650°F.

C. Welded Joints (Steel Pipe, Conduit System, Stainless Steel Pipe):

1. Welding of all pipe joints, both as to procedures and qualification of welders, shall be in accordance with Section IX, ASME "Boiler & Pressure Vessel Code" unless local codes take precedence.
2. Furnish to the Owner's Representative prior to start of work certificates qualifying each welder.
3. The Owner's Representative reserves the right to require qualifying demonstration, at the Contractor's expense, of any welders assigned to the job.
4. Ends of pipe and fittings to be joined by butt welding shall be beveled, cleaned to bare metal and internal diameters aligned before tack welding.
5. Single-welded butt joints may be employed with or without the use of backing rings in all sizes. Where backing rings are not used on pumped pressurized systems, the root side of the weld shall either be chipped or ground flush with the piping wall. For services such as vents, overflows, and gravity drains, the backing ring may be eliminated, and the root of the weld need not be chipped or ground. Backing rings shall be of the material being welded.

3.9 ACOUSTICAL LAGGING

A. Where indicated on drawings, completely wrap pipe with lagging and seal all joints airtight with tape recommended by the lagging manufacturer to prevent acoustical leakage at joints. Overlap lagging a minimum of 2" at any joint. Overlap lagging 2" at any wall, floor, or structural deck penetration to prevent acoustical leakage.

END OF SECTION 23 22 00

SECTION 23 22 18 - STEAM AND STEAM CONDENSATE SPECIALTIES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Steam Traps

B. Sample Coolers

C. Condensate Return Units

D. Pressure Reducing Valves

E. Pressure Reducing Valves Noise Suppression

F. Safety Valves

G. Vacuum Breakers

1.2 QUALITY ASSURANCE

A. Manufacturer: For each product specified, provide components by same manufacturer throughout.

B. Traps: Remanufactured traps are <u>not</u> acceptable.

1.3 SUBMITTALS

A. Submit product data under provisions of Section 23 05 00. Include product description, model, dimensions, component sizes, rough-in requirements, service sizes, and finishes.

B. Submit schedule indicating manufacturer, model number, size, location, rated capacity, and features for each specialty.

C. Submit electrical power/controls wiring diagrams and product data indicating general assembly, components, safety controls, and service connections.

D. Submit manufacturer's installation instructions.

E. Submit operation and maintenance data.

F. Submit certification that all steam and steam condensate specialties, accessories, and components will withstand seismic forces defined in Section 23 05 50. Include the following:

1. Basis for Certification: Indicate whether certification is based on actual test of assembled components or on calculation.

    a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.

3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

PART 2 - PRODUCTS

2.1 STEAM TRAPS

A. Type T-1: Inverted bucket type with thermic vent, 250 psig rated, cast iron body, side inlet and outlet, and all internal components constructed of stainless steel and renewable in-line.

1. Manufacturers (0-250 psig):

a. Armstrong Machine Works Series 800T
b. Spirax/Sacro Co., Inc. Type B
c. Hoffman Industrial Specialties Co. Series 600 T
d. Clark-Reliance Series 120

B. Type T-2: Thermostatic type with body and cap of cast brass, bronze bellows, stainless steel valve head and seat.

1. Manufacturers: (0-25 psig):

a. Spirax/Sacro Co., Inc. Type TD
b. Hoffman Industrial Specialties Co. Type C
c. Clark-Reliance Series T

C. Type T-3: Float and thermostatic type, 125 psig rated, cast iron body; balanced pressure thermostatic air vent; stainless steel valve seat, float, brass valve mechanism, and side inlet and outlet.

1. Manufacturers: (0-125 psig):

a. Armstrong Machine Works Type A
b. Hoffman Industrial Specialties Co. Series H, C, or X
c. Spirax/Sacro Co., Inc. Type FT
d. Clark-Reliance Type FT

D. Type T-4: Impulse type with stainless steel disc and body.

1. Manufacturers:

a. Armstrong Machine Works CD-60
b. Hoffman Industrial Specialties Co. Series 650
c. Spirax/Sarco Co., Inc. Type TD-52
d. Yarway Corporation, Inc. Series 30
e. Clark-Reliance Series FD

2.2 SAMPLE COOLERS

A. 316 stainless steel tube to convey steam and condensate through 316 stainless steel heat exchanger housing. All components to be stainless steel.

B. Cooler shall be rated for 215 psig (tube side) and 145 psig (cooling water side).

C. Cooler shall be capable of cooling 100 ml/min. of 295°F steam or 330 ml/min. of 185°F condensate with 6 l/min. of 68°F water.

D. Route cooling water outlet piping to nearest floor drain and provide vacuum breaker at highest point of cooling water supply piping.

E. Manufacturers:

1. Carltex, Inc. SQ2
2. Sentry DTC-4
3. Waters Equipment Co. Series 9000

2.3 LOW PRESSURE CONDENSATE RETURN UNITS (212°F, ATMOSPHERIC VENTED, HORIZONTAL ELEVATED TANK)

A. Units: Consist of factory assembled packaged receiver, strainers, pumps, float switches, control panel and accessories, for duplex operation.

B. Receiver: Horizontal, elevated above pumps, low profile, 3/16" welded steel, flat or semi-hemispherical ends, suitable for 212°F condensate, with inlets, outlets, vent, overflow, and drain connections, and lifting eye bolts.

C. Pumps: Rated to pump 212°F condensate with two (2)-foot NPSHR, with grease lubricated, sealed ball bearings, bronze impeller, stainless steel shaft, mechanical shaft seal, renewable case rings, coupled to motor, RPM as specified on the drawings, and mounted on common base plate. Refer to Section 23 05 13 for additional motor information.

D. Controls: Mechanical alternator shall be two pole; float switch shall start and stop pump. Provide control transformer for alternator if required for three-phase power.

E. Control Cabinet: Single point electrical connection, NEMA 1 or 2 enclosure, UL listed components, with hinged door, combination fused disconnect magnetic starters with overload relays, terminal strip, fusible control circuit transformer, and mechanical alternator. 'Hand-Off-Auto' switch, selector 'lead-off-lag' switches, test buttons, high level alarm light, dry contacts for high level alarm, acknowledge button and alarm horn.

F. Control Sequence: Each pump control circuit shall be completely independent of the other. Operate pumps on high level, alternating after each cycle; operate second pump upon failure of first pump and alarm.

G. Accessories: Gauge glass with isolation valves, dial thermometer pressure gauge on each pump discharge, isolation valves and suction strainer between pumps and receiver, double pole float switches, corrosion inhibitor anode, drain valve. Provide safety vapor release on receiver.

H. Capacity as scheduled on the drawings.

I. Manufacturer:

1. Roth Pump - Bulletin C204
2. Industrial Steam - Domestic CED with "B" pumps (large elevated)
3. Domestic CB with inducer impeller (small elevated)
4. Shipco HT

2.4 PRESSURE REDUCING VALVE

A. PRV-1: Self-contained type up to 4" pipe size; diaphragm actuated; pilot valve mounted on main valve, both with cast iron bodies; external mounted pilot preload screw, stainless steel springs, diaphragm, trim and seats; maximum operating pressure of 250 psig and maximum pressure drop of 230 psi.

1. Manufacturers:

a. Fisher - 92B

b. Leslie - LKY
c. Masoneilan - Type 17
d. Cashco - D
e. POSR

B. PRV-2: Externally pilot operated, single guided equal percentage plug type valve, with cast iron body and bonnet, stainless steel cage and seat for a maximum of 150 psig, with normally closed diaphragm operator. Provide yoke mounted pneumatic pressure controller with Bourdon tube sensing element, adjustable range and proportional band adjustment.

1. Manufacturers:

a. Fisher - Type 667ES w/Wizard II No. 4160
b. Leslie - Series 80
c. Masoneilan - Series 21000
d. Cashco -Model 988

C. PRV-3: Externally pilot operated, spring loaded adjustable pilot operator, single guided equal percentage plug type valve, with cast iron body and bonnet, normally closed diaphragm operator, stainless steel cage and seat for a maximum of 150 psig.

1. Manufacturers:

a. Spirax/Sarco Series 25P
b. Spence Type D
c. Hoffman Series 2000

2.5 PRESSURE REDUCING VALVES NOISE SUPPRESSION

A. Insulation Jacket: Provide high density, Teflon impregnated fiberglass mass loaded vinyl insulation jacket for pressure reducing valve and noise suppressor. Same manufacturer as pressure reducing valve.

B. Noise Suppressor: Dissipative reactive noise suppressor. Welded steel pressure shell and flanges with drain connection. Stainless steel acoustic material. Suppressor shall not induce back pressure. Flanged connections. Expanded outlet flange for attachment to downstream piping. Suppressor shall provide a minimum of 10 dBA reduction. Same manufacturer as pressure reducing valve.

C. Muffling Orifice Plate: Stainless steel plate with drilled orifices welded to stainless steel inlet screen. Orifice shall be installed between flanges downstream of noise suppressor. Design to provide minimum of 6 dBA reduction. Same manufacturer as pressure reducing valve.

2.6 SAFETY VALVES

A. SV-2: (Steam Service) Spring loaded disc type with bronze, cast iron, or steel body (steel body is required above 250 psig or 406°F, lifting lever, stainless steel disc and nozzle, and side outlet. Capacities ASME certified and labeled for Section I for boilers over 15 psig, Section IV for boilers up to 15 psig, and Section VIII for unfired pressure vessels or downstream of pressure reducing valves. Provide bellows trim where needed to compensate for piping backpressure. Include drip pan elbow with pan with NPT or flanged connection to safety valve.

1. Manufacturers:

a. Consolidated Series 1900 or 1900/P
b. Kunkle - Fig. 6030, 6252, 300, or 600
c. Keckley - Type 40 or 301

2.7 LOCK OUT TRIM

A. Provide lock out trim for all quarter turn valves opening to atmosphere installed in steam, condensate, boiler feed water piping, and as indicated on the drawings.

2.8 VACUUM BREAKER

A. Spring loaded type selected or adjusted for the minimum possible opening pressure, but never over 11" water gauge.

B. Rated for 150 psig and 366°F.

C. Manufacturers:

1. Johnson VB8
2. Sarco VB14
3. Hoffman 62
4. B&G 26

PART 3 - EXECUTION

3.1 INSTALLATION AND APPLICATION

A. General Installation Requirements:

1. Install specialties in accordance with manufacturer's instructions.
2. Size traps to handle minimum of two and one-half times maximum condensate load of apparatus served, unless noted otherwise.
3. All traps shall be minimum 3/4" size.
4. Install traps with unions or flanges at both ends.
5. Provide shutoff valve and strainer at inlet, and check valve and shutoff valve at discharge of traps.
6. Provide minimum 14" long dirt pocket of same size as apparatus return connection between apparatus and trap, unless noted otherwise on drawings.
7. Remove thermostatic elements from traps during temporary and trial usage, and until system has been operated and dirt pockets cleaned of sediment and scale.

B. Condensate Return Unit:

1. Install full-sized P-traps in the overflow drain piping from condensate return units and extend piping to nearest floor drain.

C. Pressure Reducing Valves:

1. Provide pressure reducing valve stations with pressure reducing valve, valved bypass, strainer and pressure gauge on upstream side; safety valve and pressure gauge on downstream side.
2. The size of the bypass valve at pressure reducing stations shall be one size smaller than the pressure reducing valve unless noted otherwise. Provide eccentric reducers as required. The wide-open capacity of the bypass valves shall not exceed the capacity of the relief valve.

D. Safety Valve:

1. Rate safety valves for maximum capacity of largest available trim for pressure reducing valve(s) or maximum capacity of bypass valve(s), whichever is larger, at maximum possible pressure upstream of pressure reducing valve. Set at maximum 20 percent above reduced pressure.
2. Terminate safety valves outdoors. Provide drip pan elbow with drain connection to nearest floor drain.

END OF SECTION 23 22 18

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SECTION 23 25 00 - CHEMICAL (WATER) TREATMENT

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Treatment for Closed Systems (Water).

B. Treatment for Closed Systems (Glycol).

C. Chemical Feed Equipment.

1.2 SUBMITTALS

A. Submit shop drawings under provisions of Section 23 05 00.

B. Include system schematics, equipment locations, and controls schematics.

C. Submit product data indicating chemicals and equipment.

D. Submit manufacturer's installation instructions.

E. Submit electrical power/controls wiring diagrams and product data indicating general assembly, components, safety controls, and service connections.

F. Submit reports indicating start-up of treatment systems is completed and operating properly. Include reports indicating analysis of system water after cleaning and after treatment.

1.3 EXTRA STOCK

A. Provide clean cartridges or bags in all bypass (pot) feeders with filters and sidestream filters.

B. Provide two complete sets of replacement cartridges or filters for each bypass (pot) feeder with filters and sidestream filter installed. Deliver to Owner at job site.

1.4 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data.

B. Include data on pumps and other equipment including spare parts lists, procedures, and treatment programs.

C. Include step-by-step instructions on test procedures including target concentrations and test frequencies.

D. Include list of treatment chemicals and associated SDS.

1.5 QUALIFICATIONS

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

1.6 REGULATORY REQUIREMENTS

A. Conform to all applicable codes and regulations for addition of non-potable chemicals to building mechanical systems, and for discharge to public sewage systems.

B. Provide only chemicals approved for use and disposal by local authorities. Contact the Architect/Engineer if any specified chemicals are prohibited.

1.7 MAINTENANCE SERVICE

A. Provide the following services to assist the owner in setting up and maintaining chemical treatment systems for one year from Date of Substantial Completion:

1. Provide technical service visits to perform field inspections and make water analysis on site. Visits shall be twice annually for closed systems and monthly for steam and cooling tower systems. For cooling tower systems, monthly testing shall have dipslide culture counts, and quarterly water samples shall be sent to a CDC Elite lab for culturing to establish baseline total organism and Legionella counts. Detail findings in writing on proper practices, chemical treating requirements, and corrective actions needed. Submit copies of the field service report after each visit to the Owner and to the Mechanical Contractor. Any problems related to the operation of the chemical treatment program shall be reported to the Architect/Engineer.
2. Provide laboratory and technical assistance services for warranty period.
3. Include 4 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.
4. 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.
5. Provide sufficient chemicals for treatment and testing during warranty period.

1.8 WATER ANALYSIS

A. Sample feedwater to determine appropriate chemical treatment. Contact the Architect/Engineer if test indicates treatment required is different than that specified.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Closed System Treatment (Water):

1. Provide one bypass feeder on each system. Install inlet, outlet and drain valves, and necessary piping.
2. Provide a 3/4" water meter in the domestic cold water line that provides makeup water to hydronic systems with electronic pulse output to building automation system.
3. Provide coupon rack around main system pumps for all systems

4. Proprietary blend containing the following items:

   a. Corrosion Inhibitors for Chilled Water Systems and Heating Systems operating at ≤ 145°F: Sodium molybdate with added inhibitors such as mercaptobenzothiazole, sodium tolytriazole, or phenyltriazole to protect copper and brass and minimize dielectric pitting of steel. Maintain 50 ppm molybdate. Adjust borax content to keep correct pH for type of system (mainly steel or mainly copper).
   b. Scale Inhibitor: Organic phosphonates such as aminomethylene-phosphonate; phosphonates such as hydroxyethylidenediphosphonate or polyamino-substituted phosphonates; or synthetic polymers such as low-molecular-weight polyacrylates, poly-methacrylates and polyacrylanides. Inorganic phosphates are not acceptable. Maintain residual concentration as recommended by the manufacturer.

B. Closed System Treatment (with Glycol):

1. The specified glycols contain initial charge of corrosion inhibitors, however, the pH after installation must be checked and adjusted to maintain between 8.0 and 10.0 using inhibitors recommended by the manufacturer (normally dipotassium phosphate).
2. The specified glycols contain an initial charge of corrosion inhibitors. However, the pH after installation shall be checked and adjusted to maintain between 8.0 and 8.5 using inhibitors recommended by the manufacturer (normally dipotassium phosphate). Though the system is mainly copper or steel, aluminum is present. Inhibitors shall be selected to properly protect aluminum. pH shall not exceed 8.5 to avoid disruption of the aluminum oxide film.
3. Provide coupon rack around main system pumps for all systems.

2.2 EQUIPMENT

A. Bypass (Pot) Feeder: 2.0 gal; quick-opening cap with 3-1/2" minimum diameter opening and opening wrench, legs to raise fill cap to 30" to 36", drain valve, air cock, working pressure of 200 psig at 200°F, 20 to 25-micron cartridge or bag filter.

1. Acceptable Manufacturers:

   a. Griswold
   b. Vector Industries
   c. J.L. Wingert
   d. Neptune

B. Water Meter: (Steam systems with Bypass feeder) Positive displacement type meter with bronze housing. 3/4" meter size. Meter to handle 1/2 - 30 GPM.

C. Solution Metering Pump: Positive displacement, diaphragm pump with adjustable flow rate, thermoplastic construction, continuous duty, fully enclosed electric motor and drive, and built-in relief valve.

D. Solution Tanks: May be shipping drum, 50 gallon capacity, polyethylene, self-supporting, one gallon markings, molded cover, and liquid level switch. Provide level switch in each solution tank to deactivate pump and sound local alarm.

E. Liquid Level Switch: Polypropylene housing with integrally mounted PVC air trap, receptacles for connection to metering pump, and low-level alarm light.

F. Solenoid Valves: Forged brass globe pattern body, normally open or closed as required, general purpose solenoid enclosure, and continuous duty coil.

G. Timers: Electronic timers, infinitely adjustable over full range, 150 second and five-minute range, mounted together in cabinet with hand-off-automatic switches and status lights.

H. Water Meter: Displacement type water meter with sealed, tamper-proof magnetic drive, impulse contact register, single pole, double throw dry contact switch.

I. Conductivity Controller: Packaged monitor controller with solid state circuiting, 5% accuracy, linear dial adjustment, built-in calibration switch, on-off switch and light, control function light, output to control circuit.

J. Automatic Boiler Blowdown Controller: 100-6000 microhm range, fixed or adjustable sample frequency, adjustable sample time, high and low limit alarms, 120V power requirement, nickel electrode probe, test switch, automatic blowdown valve and throttling valve.

K. Multi-Function Controllers: Electronic controllers that perform several functions such as boiler bleed-off and chemical feed are acceptable.

L. Coupon Test Rack: Compliant with ASTM D 2688-05. Fabricated of 1" diameter, Schedule 40 carbon steel or Schedule 80 PVC or CPVC, rated for the maximum expected system pressure and temperature and including the following minimum components: inlet and outlet shutoff valves, flow control valve to provide a constant velocity between 1.5 ft/s and 6 ft/s (5 GPM is acceptable for all pipe types), one coupon holder for each metal in the piping system (four minimum), and sample drain port. Support test rack independently from piping connected to sides of system piping with flow upward through test rack. Provide a coupon test rack for each open and closed loop hydronic system.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install bypass (pot) feeder with top approximately 36" above the floor.

C. Coordinate with Contractor to provide temporary metering capabilities during system fill to determine overall system volume. Notify Architect/Engineer of overall system volume so that expansion tank sizing can be confirmed.

D. For systems containing glycol, carefully review the glycol manufacturer's water requirements and coordinate to provide system cleaning, flushing, and initial fill with the proper quality of water conforming to the manufacturer's and these specifications.

3.2 CLOSED-LOOP HYDRONIC SYSTEM WATER QUALITY STANDARDS

A. Review equipment manufacturer's water quality standard to ensure water quality is sufficient to meet their warranty requirements as well as to ensure peak heat transfer efficiency. Contractor shall maintain hydronic systems within the more stringent of either the equipment manufacturer's requirements or those listed below:

Measured Value	Multi-Metal Systems with Aluminum	Multi-Metal Systems with Stainless Steel	Multi-Metal Systems with Copper
pH Range	8.5	8.5	9.0
Alkalinity as $CaCO_3$	100 - 500 mg/l	100 - 500 mg/l	100 - 500 mg/l
Hardness as $CaCO_3^*$	100 - 500 mg/l	100 - 500 mg/l	100 - 500 mg/l
Suspended Solids	less than 10 mg/l	less than 10 mg/l	less than 10 mg/l
Dissolved Solids	less than 1,000 mg/l	less than 1,000 mg/l	less than 1,000 mg/l
Chlorides	less than 150 mg/l	less than 150 mg/l	less than 150 mg/l
Iron	less than 5.0 mg/l	less than 5.0 mg/l	less than 5.0 mg/l
Manganese	less than 0.4 mg/l	less than 0.4 mg/l	less than 0.4 mg/l
Nitrate	less than 100 mg/l	less than 100 mg/l	less than 100 mg/l
Sulfate	less than 200 mg/l	less than 200 mg/l	less than 200 mg/l
Ammonia	less than 5.0 mg/l	less than 5.0 mg/l	less than 5.0 mg/l

B. Submit an independent third-party test report for each chemically treated closed-loop system showing compliance with all measured values shown in the above table as part of project closeout documentation.

C. Circulate water and verify proper chemical and especially biocide levels for six (6) hours prior to starting fans if system has been out of service.

D. Lockout all feed and bleed operations when there is no flow to cooling towers.

END OF SECTION 23 25 00

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SECTION 23 31 00 - DUCTWORK

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Galvanized Ductwork

B. Stainless Steel Ductwork

C. Ductwork Reinforcement

D. Ductwork Sealants

E. Rectangular Ductwork

F. Round and Flat Oval Ductwork

G. Exposed Ductwork (Rectangular, Round, or Oval)

H. Flexible Duct

I. Fume Exhaust Duct

J. Acoustical Lagging

K. Leakage Testing

L. Ductwork Penetrations

M. Duct Cleaning

N. Painting

1.2 SUBMITTALS

A. Submit shop drawings per Section 23 05 00.

B. Submit duct fabrication standards in compliance with SMACNA and these specifications. Clearly indicate metal gauges, reinforcement, and joining methods intended for use for each pressure classification. Furnish details of all common duct fittings and joint connections to be used on this project.

C. The Architect/Engineer may require field verification of sheet metal gauges and reinforcing to verify compliance with these specifications. At the request of the Architect/Engineer, the contractor shall remove a sample of the duct for verification. The contractor shall repair as needed.

D. Duct Layout Drawings: Submit detailed duct layout drawings at 1/4" minimum scale complete with the following information:

1. Actual duct routing, ductwork fittings, actual sheet metal dimensions including insulation liner and wrap, duct hanger and support types, ductwork accessories, etc. with lengths and weights noted.
2. Differentiate ducts that are wrapped. Include insulation thickness, type of insulation, and acoustical lagging.
3. Room names and numbers, ceiling types, and ceiling heights.

4. Indicate location of all beams, bar joists, etc. along with bottom of steel elevations for each member.
5. Verify clearances and interferences with other trades prior to preparing drawings. IMEG will provide electronic copies of ventilation drawings for contractor's use if the contractor signs and returns the "Electronic File Transfer" waiver. IMEG will not consider blatant reproductions of original file copies an acceptable alternative for this submittal. Refer also to Section 23 05 00.

E. Duct Leakage Test Summary Report: Upon completion of the pressure test described in Part 3, the Contractor shall submit an air duct leakage test summary report as outlined in the SMACNA HVAC Duct Leakage Test Manual.

1.3 DEFINITIONS

A. Duct Sizes shown on drawings are inside clear dimensions. Maintain clear dimensions inside any lining.

B. Transitions are generally not shown in single-line ductwork. Where sizes change at a divided flow fitting, the larger size shall continue through the fitting.

C. Exterior Duct: Ductwork located outside the conditioned envelope including exposed ductwork above the roof, outside exterior walls, in attics above insulated ceilings, inside parking garages, and crawl spaces.

D. Interior Duct: Ductwork located within the conditioned envelope including return air plenums and indirectly conditioned spaces.

1.4 COORDINATION DRAWINGS

A. Reference Coordination Drawings article in Section 23 05 00 for required duct systems electronic CAD drawings to be provided to Coordinating Contractor for inclusion into composite coordination drawings.

B. Duct drawings shall be at 1/4" minimum scale complete with the following information:

1. Actual duct routing, ductwork fittings, actual sheet metal dimensions including insulation liner and wrap, duct hanger and support types, ductwork accessories, etc. with lengths and weights noted.
2. Differentiate ducts that are lined or wrapped. Include insulation thickness, type of insulation, and acoustical lagging.
3. Location and size of all duct access doors.
4. Room names and numbers, ceiling types, and ceiling heights.
5. Indicate location of all beams, bar joists, etc. along with bottom of steel elevations for each member.
6. IMEG will provide electronic file copies of ventilation drawings for contractor's use if the contractor signs and returns an "Electronic File Transfer" waiver provided by IMEG. IMEG will not consider blatant reproductions of original file copies an acceptable alternative for coordination drawings. Architectural plans will need to be obtained from the Architect.

PART 2 - PRODUCTS

2.1 SHAPE

A. Rectangular Duct - Single Wall:

1. General Requirements:

a. All ductwork gauges and reinforcements shall be as listed in SMACNA Duct Construction Standards Chapter 2. Where necessary to fit in confined spaces, furnish heaviest duct gauge and least space consuming reinforcement.
b. Transitions shall not exceed the angles in Figure 4-7.

2. Exceptions and modifications to the 2005 HVAC Duct Construction Standards are:

   a. All ducts shall be cross-broken or beaded.
   b. Snap lock seams are not permitted.
   c. Turning vanes shall be used in all 90° mitered elbows, unless clearly noted otherwise on the drawings. Vanes shall be as follows:

      1) Type 1:

         a) Description: Single wall type with 22-gauge (0.029") or heavier vanes, 3-1/4" blade spacing, and 4" to 4-1/2" radius. Vanes hemmed if recommended by runner manufacturer. Runners shall have extra-long locking tabs. C-value independently tested at below 0.26. EZ Rail II by Sheet Metal Connectors or equal.
         b) Usage: Limited to 3,000 fpm and vane lengths 36" and under.

      2) Type 2:

         a) Description: Double wall type with 3-1/4" blade spacing, 4-1/2" radius, 24-gauge minimum, and SMACNA Type 1 runners. C-value below 0.27.
         b) Usage: No limits other than imposed by the manufacturer. Provide intermediate support for vanes over 48" long.

      3) Type 3 (acoustical - where acoustical lagging is located or as noted on drawings):

         a) Description: Same as Type 2, except filled with fiberglass and with slotted or perforated inner curve. Minimum insertion loss of 9 dB at 250 Hz and 6 dB at 1 KHz.
         b) Usage: No limits other than imposed by the manufacturer. Provide intermediate support for vanes over 48" long.

      4) Turning vanes shall operate quietly. Repair or replace vanes that rattle or flutter.
      5) Runners must be installed at a 45° angle. Elbows with different size inlet and outlet must be radius type.
      6) Omitting every other vane is prohibited.

   d. Where smooth radius rectangular elbows are shown, they shall be constructed per SMACNA Figure 4-2. Type RE1 shall be constructed with a centerline duct radius R/W of 1.0. Where shown on drawings, Type RE3 elbows with 3 vanes shall be used with centerline duct radius R/W of 0.6 (SMACNA r/W=0.1). RE1 or RE3 elbows may be used where mitered elbows are shown if space permits. Mitered elbows (with or without turning vanes) may not be substituted for radius elbows. Do not make branch takeoffs within 4 duct diameters on the side of the duct downstream from the inside radius of radius elbows.
   e. Rectangular branch and tee connections in ducts over 1" pressure class shall be 45° entry type per Figs. 4-5 and 4-6. Rectangular straight taps are not acceptable above 1" pressure class.
   f. Bellmouth fittings shown on return duct inlets shall expand at a 60-degree total angle horizontally and vertically (space permitting) and have length of at least 25% of the smallest duct dimension.
   g. Round taps off rectangular unlined ducts shall be flanged conical or bellmouth type (equal to Buckley Bellmouth or Sheet Metal Connectors E-Z Tap), or 45° rectangular with transition to round (equal to Sheet Metal Connectors Inc. High Efficiency Takeoff). Straight taps are acceptable if pressure class is 1" or less, round duct is 12" diameter or less, and the tap is not located between fans and TAB devices.
   h. Duct offsets shall be constructed as shown on drawings. Additional offsets required in the field shall be formed of mitered elbows without turning vanes for offsets up to 30° maximum angle in accordance with SMACNA offset Type 2. Offsets of greater than 30° angle shall be formed of radius elbows with centerline radius R/W=1.0 or greater. SMACNA Type 1 offsets are not permitted.
   i. All lined duct shall utilize dovetail joints where round or conical taps occur. The dovetail joints shall extend past the liner before being folded over.

j. Cushion heads are acceptable only downstream of TAB devices in ducts up to ± 2" pressure class, and must be less than 6" in length.
k. Slide-on flanged transverse joint systems are acceptable provided they are a manufactured product that has been tested for conformance with Chapter 2 of the SMACNA HVAC Duct Construction Standards for sheet and joint deflection at the specified pressure class.

1) Apply sealant to all inside corners. Holes at corners are not acceptable.
2) Manufacturers:

a) Ductmate Industries - 25/35/45
b) Nexus
c) Mez
d) WDCI
e) Other manufacturers must submit test data and fabrication standards and receive Architect/Engineer's approval before any fabrication begins.

l. Formed-on flanged transverse joint systems are acceptable provided they are a manufactured product that has been tested for conformance with Chapter 2 of the SMACNA HVAC Duct Construction Standards for sheet and joint deflection at the specified pressure class.

1) Apply sealant to all inside corners. Holes at corners are not acceptable.
2) Flanges shall be 24-gauge minimum (not 26 gauge).
3) Manufacturers:

a) Lockformer TDC
b) TDF
c) United McGill
d) Sheet Metal Connectors
e) Other manufacturers must submit test data and fabrication standards and receive Architect/Engineer's approval before any fabrication begins.

B. Rectangular Duct - Double Wall:

1. All applicable portions of Rectangular Duct - Single Wall shall apply.
2. Furnish and install double-wall insulated airtight duct as shown on the drawings.
3. Duct Construction:

a. Galvanized steel exterior wall with solid galvanized steel interior wall.
b. Rectangular double wall duct shall be suitable for pressures listed in the ductwork application schedule.

c. All ductwork gauges and reinforcement shall be as listed in SMACNA Duct Construction Standards Chapter 2. Where necessary to fit in confined spaces, furnish heaviest duct gauge and least space-consuming reinforcement.
d. Ducts shall be 1" thick and completely metal enclosed with annular space completely filled with 1-1/2# density glass fiber insulation. Insulation shall have flame spread/smoke developed ratings of less than 25/50 per ASTM E84, NFPA 255, or UL 723.
e. Divided flow fittings may be separate fittings or factory installed taps with the following construction requirements:

1) Airtight, continuous welds at intersection of fitting body and tap.
2) Tap liner spot welded to inner liner with weld spacing not over 3".
3) Insulation packed around the tap area for complete cavity filling.
4) Carefully fit branch connections to cut-out openings in inner liner without spaces for air erosion of insulation or sharp projections for noise and airflow disturbance.

f. Spot weld and bond all fitting seams in the pressure shell. Coat galvanizing damaged by welding with corrosion resistant paint to match galvanized duct color.

g. Support inner liner of ducts and fittings with metal spacers welded to maintain spacing and concentricity.
h. Formed-on flanged transverse joint systems are acceptable if they are a manufactured product that has been tested for conformance with Chapter 2 of the SMACNA HVAC Duct Construction Standards for sheet and joint deflection at the specified pressure class.

1) Apply sealant to all inside corners. Holes at corners are not acceptable.
2) Flanges shall be 24-gauge minimum (not 26 gauge).
3) Manufacturers, Formed-on Flanged Joint Systems:

a) Lockformer TDC
b) TDF
c) United McGill
d) Sheet Metal Connectors
e) Other manufacturers must submit test data and fabrication standards and receive Architect/Engineer's approval before any fabrication begins.

C. Round and Flat Oval Spiral Seam Ductwork - Single Wall:

1. Conform to applicable portions of Rectangular Duct Section. Round or flat oval ductwork may be substituted for rectangular ductwork where approved by the Architect/Engineer. The spiral seam ductwork shall meet the standards set forth in this specification. The ductwork shall meet or exceed the specified cross-sectional area and insulation requirements. The substitution shall be coordinated with all other trades prior to installation.

2. Flat oval duct in negative pressure applications shall have flat sides reinforced as required for rectangular ducts of the same gauge with dimensions equal to the flat span of the oval duct.
3. 90° elbows shall be smooth radius or have a minimum of five sections with mitered joints and R/D of at least 1.5.
4. Duct and fittings shall meet the required minimum gauges listed in chapter 3 of the SMACNA requirements for the specified pressure class. Ribbed and lightweight duct are not permitted.
5. Ductwork shall be suitable for velocities up to 5,000 fpm.
6. Divided flow fittings may be made as separate fittings or factory installed taps with sound, airtight, continuous welds at intersection of fitting body and tap.
7. Spot weld and bond all fitting seams in the pressure shell. Coat galvanizing damaged by welding with corrosion resistant paint to match galvanized duct color.
8. Ducts with minor axis less than 22" shall be spiral seam type. Larger ducts may be rolled, longitudinal welded seam type. SMACNA seams RL-2 and RL-3 are not permitted.
9. Reinforce flat oval ducts with external angles. Internal tie rods are permitted only as indicated for rectangular ductwork.
10. Transverse Joint Connections:

a. Crimped joints are not permitted.
b. Ducts and fittings 36" in diameter and smaller shall have slip joint connections. Size fitting ends to slip inside mating duct sections with minimum 2-inch insertion length and a stop bead. Use inside slip couplings for duct-to-duct joints, and outside slip couplings for fitting-to-fitting joints.
c. Ducts and fittings larger than 36" shall have flanged connections.
d. Secure all joints with at least 3 sheet metal screws before sealing.
e. Manufacturers:

1) Slide-on Flanges:
2) Ductmate Industries - SpiralMate
3) Accuflange
4) Sheet Metal Connectors are acceptable.

f. Manufacturers, Self-Sealing Duct Systems:

1) Lindab
2) Ward "Keating Coupling"

D. Round and Flat Oval Spiral Seam Ductwork - Double Wall:

1. Conform to applicable portions of Rectangular Duct Section. Spiral seam round or flat oval double wall ductwork may be substituted for double wall rectangular ductwork where approved by the Architect/Engineer. Double wall spiral seam ductwork shall meet the standards set forth in this specification. Ductwork shall meet or exceed the specified cross-sectional area and insulation requirements. The substitution shall be coordinated with all other trades prior to installation.

2. Interior ducts shall have an airtight outer pressure shell, a 1" insulation layer, and a solid inner wall that completely covers the insulation.
3. Exterior ducts shall have an airtight outer pressure shell, a 2" insulation layer, and a solid inner wall that completely covers the insulation.
4. Insulation shall have flame spread/smoke developed ratings of under 25/50 per ASTM E84, NFPA 255, or UL 723.
5. 90° elbows shall be smooth radius or have a minimum of 5 mitered joints, and R/D of at least 1.5.
6. Duct and Fittings shall meet the required minimum gauges listed in chapter 3 of the SMACNA standards for the specified pressure class. Ribbed and lightweight duct are not permitted.
7. Ductwork shall be suitable for up to 5,000 fpm velocity.
8. Divided flow fittings may be separate fittings or factory installed taps with the following construction requirements:

   a. Sound airtight, continuous welds at intersection of fitting body and tap.
   b. Tap liner welded to inner liner with weld spacing not over 3".
   c. Insulation packed around the tap area for complete cavity filling.
   d. Carefully fit branch connections to cut-out openings in inner liner without spaces for air erosion of insulation or sharp projections for noise and airflow disturbance.

9. Spot weld and bond all fitting seams in the pressure shell. Coat galvanizing damaged by welding with corrosion resistant paint to match galvanized duct color.
10. Support inner liner of ducts and fittings with metal spacers welded to maintain spacing and concentricity.
11. Ducts with minor axis under 22" shall be spiral seam type. Larger ducts may be rolled, longitudinal welded seam type. SMACNA seams RL-2 and RL-3 are not permitted.
12. Transverse Joint Connections:

   a. Crimped joints are not permitted.
   b. Provide couplings to align the inner liners. Butt joints are not permitted for inner liners. Make alignment by extending the liner of the fitting into the duct or by using a double concentric coupling with the two couplings held by spacers for rigidity and wall spacing.
   c. Above 34" ID provide a separate coupling for inner alignment with the pressure shells joined by angle ring flanged connections.
   d. Use outside slip couplings for fitting-to-fitting joints.
   e. Secure all joints with at least 3 sheet metal screws before sealing.
   f. Manufacturers

      1) Slide-on Flanges:
      2) Ductmate Industries - SpiralMate
      3) Accuflange
      4) Sheet Metal Connectors

   g. Manufacturers, Self-Sealing Duct System:

      1) Lindab
      2) Ward "Keating Coupling"

E. Round Snap-Lock Seam Ductwork - Single Wall:

1. Factory sealed snap-lock pipe. Transverse and longitudinal seams shall contain factory-applied self-sealing EPDM and co-polymer gasket. Snap-lock shall conform to SMACNA RL-8. Duct and gasket material shall meet the flame/smoke spread rating of 25/50 per ASTM-E84.

2. G-60 galvanized coating meeting ASTM A653 and ASTM A90 G-90 galvanized steel aluminum meeting ASTM B209 Alloy 3003 Temper H14 304 stainless steel meeting ASTM A480 2B Finish.
3. Snap-lock seams are only permitted on systems between -1"w.c. and 2"w.c. pressure class.
4. 90° elbows shall be smooth radius or have a minimum of five sections with mitered joints and R/D of at least 1.5.
5. Duct and fittings shall meet the required minimum gauges listed in Chapter 3 of the SMACNA requirements for the specified pressure class.
6. Divided flow fittings may be made as separate fittings or factory installed taps with sound, airtight, continuous welds at intersection of fitting body and tap.
7. Spot weld and bond all fitting seams in the pressure shell. Coat galvanizing damaged by welding with corrosion resistant paint to match galvanized duct color.
8. Manufacturers:

    a. GreenSeam Industries.

2.2 MATERIAL AND APPLICATION SPECIFIC

A. Galvanized Steel:

1. General Requirements:

    a. Duct and reinforcement materials shall conform to ASTM A653 and A924.
    b. Interior Ductwork and reinforcements: G60 galvanized (0.60 ounces per square foot total zinc coating for two sides per ASTM A90) unless noted otherwise.
    c. Exterior Ductwork: G90 galvanized (0.90 ounces per square foot total zinc coating for two sides per ASTM A90) unless noted otherwise. G60 is not acceptable for exterior use.
    d. Ductwork reinforcement shall be of galvanized steel.

2. Duct Hangers and Support:

    a. Ductwork supports shall be of galvanized or painted steel.
    b. All fasteners shall be galvanized or cadmium plated.
    c. Strap Hangers: Strap hanger shall be a minimum of 1 inch, 18 gauge galvanized steel attached to the bottom of ducts with spacing as required by SMACNA.

B. Stainless Steel Ductwork:

1. General Requirements:

    a. Ductwork shall be Type 316L stainless steel, 16 gauge minimum.
    b. Exposed ductwork shall have a #3 finish. Concealed ductwork may have milled finish.
    c. Ductwork reinforcement shall be of stainless steel.

2. Duct Hangers and Supports:

    a. Ductwork supports shall be of stainless steel. Slip cable hangers are acceptable.

        1) Manufacturers, Supports:

            a) Gripple
            b) Ductmate
            c) Duro Dyne
            d) Architect/Engineer approved

    b. All fasteners shall be cadmium plated or stainless steel.

C. Exposed Ductwork (Rectangular, Round, and Flat Oval):

1. The following applies to all ductwork exposed in finished areas in addition to requirements noted above:

   a. Provide extra shipping protection. Use Cardboard or other protective means to prevent dents and deformed ends.
   b. Provide cardboard or other means of protection during field fabrication. Protect from scratches. Provide stiffeners to retain shape during fabrication.
   c. Remove all identification stickers and thoroughly clean exterior of all ducts.
   d. Locate fitting seams on least visible side of duct.
   e. Provide exterior finish suitable for field painting without further oil removal.
   f. Provide ramp-type internal joint couplings. Provide bead of sealant around the inside of the duct about 1/2" from the end of the duct.
   g. Manufacturers, Slide-on Flanges:

      1) Ductmate Industries
      2) Accuflange
      3) Sheet Metal Connectors

   h. Manufacturers, Self-Sealing Duct System:

      1) Lindab
      2) Ward "Keating Koupling"

   i. The system shall be free of visible dents and scratches when viewed from normal occupancy.
   j. All insulation shall be internal, except at reheat coils.

2. In addition to the paragraphs above, this section applies to all ductwork specified or shown as "Architecturally Exposed":

   a. All spiral ductwork fittings shall be carbon arc welded.
   b. Grind all welds to remove irregularities.
   c. Conical taps shall be one piece. Taps for grilles and takeoffs shall be factory installed with a continuous weld and ground smooth.
   d. Welds shall be ground smooth and painted.
   e. All architecturally exposed ducts shall be round or flat oval except where not possible (grilles, reheat coils, etc.).

3. Alternate manufacturers, including shop fabricated duct, must be reviewed before installation. The following information is required:

   a. Metal gauge of duct and fittings.
   b. Fitting type and construction.
   c. Type and size of reinforcement.

4. Hangers for Exposed Ductwork:

   a. Round Ducts:

      1) Threaded rod with duct fixing bracket and metal strap. Provide single threaded rod centered on the duct. Strap hanger shall be a minimum of 1 inch, 18 gauge galvanized steel wrapping the circumference of the duct. Spacing as required by SMACNA guidelines.
      2) Aircraft cable and slip cable hangers are acceptable for ducts up to 18" diameter. Protective sleeve tubing shall be used on the cable when supporting duct with exterior insulation. Spacing and cable size as required by SMACNA guidelines.

a) Manufacturers, Supports: Gripple, Ductmate, Duro Dyne, Architect/Engineer approved.

3) Aircraft cable with 2-point support in standard horseshoe arrangement. Protective sleeve tubing shall be used on the cable when supporting duct with exterior insulation. Spacing and cable size as required by SMACNA guidelines.

b. Rectangular Ducts:

1) Aircraft cable and slip cable hangers are acceptable for ducts up to 18" in maximum dimension. Protective sleeve tubing shall be used on the cable when supporting duct with exterior insulation. Corner saddles are required when supporting rectangular ductwork. Spacing and cable size as required by SMACNA guidelines.

a) Manufacturers, Supports: Gripple, Ductmate, Duro Dyne, Architect/Engineer approved.

2) Aircraft cable with 2-point support in standard horseshoe arrangement. Protective sleeve tubing shall be used on the cable when supporting duct with exterior insulation. Corner saddles are required when supporting rectangular ductwork.

c. Strut-channel and all-thread rod is not acceptable for exposed ductwork.
d. All fasteners shall be galvanized or cadmium plated.

D. Fume Exhaust Duct:

1. Stainless Steel:

a. Unless shown otherwise on the drawings, all fume exhaust ductwork shall be 14 gauge Type 304L stainless steel with continuously welded joints. Ductwork shall meet all requirements of SMACNA Class 5-6" pressure class industrial ductwork. Use heavier gauge and/or transverse reinforcements if required.
b. Elbows up to 30° shall be mitered two-piece type. Elbows 31° to 50° shall be mitered three-piece type. Elbows 51° to 90° shall be mitered five-piece type. All elbows shall have a minimum centerline R/D of 1.5. Elbows 10" in diameter and smaller may be die-formed.
c. Expanders in horizontal ducts shall be eccentric type with a minimum length of (diameter change x 10) and shall maintain a positive pitch for drainage to the fume hood or exhaust outlet. Expanders in ducts over 30° from horizontal shall be concentric with a minimum length of (diameter change x 5).
d. Ducts shall maintain the maximum possible pitch toward their inlets unless a different drainage location is indicated on the drawings. If at least 1/8" per foot pitch cannot be maintained, notify the Architect/Engineer before installing ductwork or other items with which ductwork may conflict.
e. All welds shall conform to AWS D9.1M. Welds shall be Gas Tungsten Arc Weld (TIG) or Gas Metal Arc Weld (MIG) type. All filler metal shall conform to AWS A5.9 or A5.22 and be AWS Classification ER308L or ER308LSi with a carbon content of not over 0.03%.
f. Supports shall not penetrate duct surfaces. Ductwork shall be completely leak-tight from the inlet to the discharge to the atmosphere, at pressures up to 10" WG. Install caps to seal the ductwork for pressure testing. Plug all spray and drain connections when testing ductwork.
g. Where flanged joints are indicated, they shall have 1/4" "Gore-Tex Joint Sealant" gaskets (W. L. Gore & Associates, Industrial Products Division, 100 Airport Road, Box 1550, Elkton, MD 21921 (410) 392-4440 or (410) 392-3200). PTFE gaskets are also acceptable.
h. Furnish one 50' spool of gasket material or 10 spare gaskets of each size used to the Owner for future use.
i. All ducts indicated as "316SS" shall be constructed of Type 316L stainless steel. The specification above for 304L stainless steel ductwork also applies to 316L stainless steel ductwork except all filler metal shall be AWS Classification ER316L with a carbon content of not over 0.03%.
j. Do not penetrate fire rated partitions, unless protected as required by applicable codes.

2.3 DUCTWORK REINFORCEMENT

A. All reinforcement shall be external to the duct except that tie rods may be used with the following limitations.

1. Ducts must be over 18" wide.
2. Duct dimensions must be increased 2" in one dimension (h or w) for each row of tie rods installed.
3. Tie rods must not exceed 1/2" diameter.
4. Manufacturer of tie rod system must certify pressure classifications of various arrangements, and this must be in the shop drawings.

2.4 DUCTWORK SEALANTS

A. One-part joint sealers shall be water-based mastic systems that meet the following requirements: maximum 48-hour cure time, service temperature of -20°F to +175°F, resistant to mold, mildew and water, flame spread rating below 25 and smoke-developed rating below 50 when tested in accordance with ASTM E84, suitable for all SMACNA seal classes and pressure classes. Mastic used to seal flexible ductwork shall be marked UL 181B-M.

B. Two-part joint sealers shall consist of a minimum 3" wide mineral-gypsum compound impregnated fiber tape and a liquid sealant. Sealant system shall meet the following requirements: maximum 48-hour cure time, service temperature of 0°F to 200°F, resistant to mold, mildew, and water, flame spread rating below 25 and smoke developed rating below 50 when tested in accordance with ASTM E84, suitable for all SMACNA seal classes and pressure classes.

C. Pressure sensitive tape used for sealing ductwork shall be minimum 2.5-inch wide, listed and marked UL 181A-P, having minimum 60 oz/inch peel adhesion to steel, and service temperature range from -20°F to +250°F.

D. Where pressure sensitive tape is called for on drawings and specifications for sealing flexible ductwork, tape shall be minimum 2.5-inch wide, UL 181 B-FX listed, and marked tape having minimum 60 oz/inch peel adhesion to steel and service temperature range from -20°F to +250°F.

1. Manufacturers, Pressure-Sensitive Tape:

   a. Venture Tape 1581A
   b. Compac #340
   c. Scotch Foil Tape 3326
   d. Polyken 339

2.5 FLEXIBLE DUCT

A. Flexible duct shall be listed and labeled as UL 181 Class 1 Air Duct Material, and shall comply with NFPA 90A and 90B, and meet GSA, FHA and other U.S. Government agency standards. Flexible duct shall bear the ADC Seal of Certification.

B. Flame Spread/Smoke Developed: Not over 25/50.

C. Stretch all flexible duct to prevent sags and reduce air friction. Shorten and reinstall all sagging or loose flexible duct. Avoid sharp elbows. Elbows shall maintain 1.5 diameter centerline turning radius.

D. Install per the SMACNA Flexible Duct Manual. Secure inner layer with draw band. Wrap with pressure sensitive tape for protection prior to installing draw band. Pressure sensitive tape alone is not acceptable.

E. Acoustic:

1. Flexible duct shall be acoustic rated in accordance with ASTM E477 and ADC Test Code FD 72-RI by ETL. Insertion loss values noted below are for flow velocities less than 2,500 fpm. Submittals shall include insertion losses ratings per sizes and lengths listed below regardless of sizes shown on the drawings.
2. Inner liner shall be airtight and suitable for 6" WC static pressure through 16" diameter. Outer jacket shall act as a vapor barrier only with permeance not over 0.1 perm per ASTM E96, Procedure A. "R" value shall not be less than 4.0 ft 2*ºF*hr/Btuh. Temperature range of at least 0-180ºF. Maximum velocity of 4,000 fpm.
3. Minimum Acoustic Insertion Losses per octave band:

a. Straight Duct:

Dia	Length	63hz	125hz	250hz	500hz	1000hz	2000hz	4000hz
6" Ø	6 ft	4.0	13	15	15	16	17	16
6" Ø	3 ft	2.3	4.9	5.3	5.3	5.5	5.8	5.4
8" Ø	6 ft	5.7	14	13	15	16	18	16
8" Ø	3 ft	2.9	5.0	4.9	5.7	5.6	5.8	5.6
12" Ø	6 ft	5.5	13	12	15	15	18	13
12" Ø	3 ft	2.8	4.8	4.7	5.3	5.3	5.8	4.9

b. 90deg Elbow:

Dia	Length	63hz	125hz	250hz	500hz	1000hz	2000hz	4000hz
6" Ø	6 ft	10	15	16	17	18	17	18
6" Ø	3 ft	3.8	5.4	5.5	5.7	5.9	5.8	5.9
8" Ø	6 ft	10	15	16	17	16	18	18
8" Ø	3 ft	2.4	5.3	5.6	5.8	5.6	5.9	6.0
12" Ø	6 ft	11	14	15	16	15	16	15
12" Ø	3 ft	4.4	5.1	5.3	5.5	5.4	5.6	5.3

4. Usage:

a. Take-offs from supply ducts to inlets of terminal air boxes. Do not exceed 36" in length.
b. Connections to air inlets and outlets. Do not exceed 6'-0" in length.
c. Acceptable Manufacturers:

1) Flexmaster USA - Type 6
2) Thermaflex M-Ke

F. Radius Forming Elbows:

1. Flexible plastic radius forming elbow for use with flexible ducts to create 90deg elbow. One size for 6" to 16" diameter ducts. UL listed for return plenum spaces.
2. Usage: All supply air terminals with flexible ductwork connection.
3. Installation: Attach to flex duct and secure draw bands without crushing flex duct to form smooth radius elbow. Suspend radius forming elbow to structure. Install per manufacturer's instructions.

4. Acceptable Manufacturers:

   a. Hart & Cooley - Smartflow
   b. Thermaflex - Flexflow
   c. Titus - Flexright

2.6 ACOUSTICAL LAGGING

A. Type A: Lagging shall be a loaded vinyl noise barrier, fiberglass scrim facing, and 1" thick quilted fiberglass decoupling layer. Lagging shall have a minimum STC of 28, and Class A flammability (maximum 25/50) rating per ASTM E-84. Install lagging per manufacturer's recommendations.

   1. Manufacturers, Type A Lagging:

      a. Sound Seal B-10 Lag/QFA-3
      b. McGill Air Pressure PDL-3
      c. Kinetics KNM 100ALQ-1

B. Type B: Lagging shall be a loaded vinyl noise barrier, fiberglass scrim facing, and 2" thick quilted fiberglass decoupling layer. Lagging shall have a minimum STC of 30, and Class A flammability (maximum 25/50) rating per ASTM E-84. Install lagging per manufacturer's recommendations.

   1. Manufacturers, Type B Lagging:

      a. Sound Seal B-10 Lag/QFA-9
      b. McGill Air Pressure PDL-9

C. Refer to drawings for acoustical lagging locations.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Provide openings in ducts for thermometers and controllers.

B. Locate ducts with space around equipment for normal operation and maintenance.

C. Do not install ducts or other equipment above electrical switchboards or panelboards. This includes a dedicated space extending 25 feet from the floor to the structural ceiling with width and depth equal to the electrical equipment. Unless intended to serve these rooms, do not install any ductwork or equipment in electrical rooms, transformer rooms, electrical closets, telephone rooms or elevator machine rooms.

D. Provide temporary closures of metal or taped polyethylene on open ducts to prevent dust from entering ductwork.

E. Supply ductwork shall be free of construction debris, and shall comply with Level "B" of the SMACNA Duct Cleanliness for New Construction Guidelines.

F. Repair all duct insulation and liner tears.

G. Install manual volume dampers in branch supply ducts so all outlets can be adjusted. Do not install dampers at air terminal device or in outlets, unless specifically shown.

H. Insulate terminal air box reheat coils. Seal insulation tight to form a tight vapor barrier.

I. Install flexible duct in accordance with the ADC Flexible Duct Performance and Installation Standards.

J. Flexible duct shall NOT be joined to flat-oval connections. Provide sheet metal oval-to-round transitions where required, to include, but not limited to, all connections to air inlets, air outlets, and terminal air boxes.

K. Install all exterior ductwork per SMACNA Fig. 6-3. Where drawings do not indicate otherwise, ductwork seams and joints shall be sealed watertight and pitched to shed water.

L. Support all duct systems in accordance with the SMACNA HVAC Duct Construction Standards: Metal and Flexible and the SMACNA Seismic Restraint Manual: Guidelines for Mechanical Systems, where applicable. Refer to Section 23 05 50 for seismic requirements.

M. Adhesives, sealants, tapes, vapor retarders, films, and other supplementary materials added to ducts, plenums, housing panels, silencers, etc. shall have flame spread/smoke developed ratings of under 25/50 per ASTM E84, NFPA 255, or UL 723.

N. All duct support shall extend directly to building structure. Do not support ductwork from pipe hangers unless coordinated with piping contractor prior to installation. Do not allow lighting or ceiling supports to be hung from ductwork or ductwork supports.

3.2 DUCTWORK APPLICATION SCHEDULE

A. General:

1. Seal Class is per SMACNA HVAC Air Duct Leakage Test Manual
2. Insulation:

a. Refer to Section 23 07 13 for insulation types.
b. Type A insulation (Flexible Fiberglass Wrap) R-values noted are based on installed values (25% compression).

3. Note 1: Apply aluminum based adhesive sealant tape at non-flanged joints on ducts serving dedicated outside air supply (DOAS) and exhaust system in addition to Class A sealant.
4. Note 2: Apply aluminum based adhesive sealant tape on TAB boxes (all seams and joints of the box and duct connections) serving dedicated outside air supply (DOAS) system.

B. Supply Duct from Fan to Terminal Air Boxes - Single Wall:

1. Shape:

a. Rectangular Duct - Single Wall
b. Round and Flat Oval Spiral Seam Ductwork - Single Wall

2. Material: Galvanized Steel
3. Pressure Class: +4"
4. Seal Class: A
5. Insulation:

a. IECC-2021: 1-1/2" thick Type A (R=4.5)

6. Additional Requirements: None

C. Supply Duct from Fan to Terminal Air Boxes - Double Wall:

1. Shape:

a. Rectangular Duct - Double Wall
b. Round and Flat Oval Spiral Seam Ductwork - Double Wall

2. Material: Galvanized Steel
3. Pressure Class: +6"
4. Seal Class: A
5. Insulation:

    a. IECC-2021: 1" thick Type E (R=3.7)

6. Additional Requirements: None

D. Supply Duct from Terminal Air Boxes to Outlets:

1. Shape:

    a. Rectangular Duct - Single Wall
    b. Round and Flat Oval Spiral Seam Ductwork - Single Wall
    c. Round Snap-Lock Seam Ductwork - Single Wall

2. Material: Galvanized Steel
3. Pressure Class: +2"
4. Seal Class: A
5. Insulation:

    a. IECC-2021: 1-1/2" thick Type A (R=4.5)

6. Additional Requirements: None

E. Return Duct:

1. Shape:

    a. Rectangular Duct - Single Wall
    b. Round and Flat Oval Spiral Seam Ductwork - Single Wall

2. Material: Galvanized Steel
3. Pressure Class: -2"
4. Seal Class: A
5. Insulation:

    a. IECC-2021: None

6. Additional Requirements: None

F. General Exhaust Duct:

1. Shape:

    a. Rectangular Duct - Single Wall
    b. Round and Flat Oval Spiral Seam Ductwork - Single Wall

2. Material: Galvanized Steel
3. Pressure Class: -1"
4. Seal Class: A
5. Insulation: None
6. Additional Requirements: None

G. Relief/Exhaust Air Duct from Fan to Exhaust Outlet:

1. Shape:

a. Rectangular Duct - Single Wall
b. Round and Flat Oval Spiral Seam Ductwork - Single Wall

2. Material: Galvanized Steel
3. Pressure Class: +2"
4. Seal Class: A
5. Insulation:

a. IECC-2021: 1-1/2" thick Type A (R=4.5)

H. Fume Exhaust Duct:

1. Shape: Refer to "Fume Exhaust Duct"
2. Material: Stainless Steel
3. Pressure Class: -6"
4. Seal Class: A

Insulation: none Outside Air Intake from Louver to Heating Coil:

5. Shape:

a. Rectangular Duct - Single Wall
b. Round and Flat Oval Spiral Seam Ductwork - Single Wall

6. Material: Galvanized Steel
7. Pressure Class: -2"
8. Seal Class: A
9. Insulation: 1 1/2" thick Type B (R=6.0)

I. Transfer Ducts:

1. Shape:

a. Rectangular Duct - Single Wall
b. Round and Flat Oval Spiral Seam Ductwork - Single Wall

2. Material: Galvanized Steel
3. Pressure Class: -1/2"
4. Seal Class: A
5. Insulation: 1" thick Type C (R=3.6)

J. Ductwork Accessories (Fabric Flex Connectors, Equipment Flanges, etc.):

1. Insulation:

a. IECC-2021: 1-1/2" thick Type A (R=4.5)

K. All Terminal Air Box/ Reheat Coil Headers and Duct Mounted Coil Headers:

1. Insulation: 1-1/2" thick Type A (R=4.5)

L. Linear Diffuser Supply Plenum:

1. Insulation:

a. IECC-2021: 1-1/2" thick Type A (R=4.5)

3.3 DUCTWORK SEALING

A. General Requirements:

1. Openings, such as rotating shafts, shall be sealed with bushings or similar.
2. Pressure sensitive tape shall not be used as the primary sealant unless it has been certified to comply with UL-181A or UL-181B by an independent testing laboratory and the tape is used in accordance with that certification.
3. All connections shall be sealed including, but not limited to, taps, other branch connections, access doors, access panels, and duct connections to equipment. Sealing that would void product listings is not required. Spiral lock seams need not be sealed.
4. Mastic-based duct sealants shall be applied to joints and seams in minimum 3 inch wide by 20 mil thick bands using brush, putty knife, trowel, or spray, unless manufacturer's data sheet specifies other application methods or requirements.

B. All ducts systems, regardless of pressure class, shall be Seal Class A as defined by Section 5-1 of SMACNA HVAC Air Duct Leakage Test Manual per the Energy Code, unless specifically noted otherwise. Seal Class A shall include sealing of all transverse joints, longitudinal seams, and duct wall penetrations with welds, gaskets, mastics, or fabric-embedded mastic system. Joints are inclusive of, but not limited to, girth joints, branch and sub-branch intersections, duct collar tap-ins, fitting subsections, louver and air terminal connections to ducts, access door and access panel frames and jambs, duct, plenum, and casing abutments to building structures.

C. Double-wall ductwork: Install insulation end fittings at all transitions from double to single-wall construction.

3.4 TESTING

A. Interior Duct - Less than 3" WG (positive or negative):

1. Leak testing of these pressure classes is not normally required for interior ductwork (inside the building envelope). However, leak tests will be required if, in the opinion of the Architect/Engineer, the leakage appears excessive. All exterior ductwork shall be tested. If duct has outside wrap, testing shall be done before it is applied.
2. Leak test shall be at the Contractor's expense and shall require capping and sealing all openings.
3. Seal ducts to bring the air leakage into compliance.
4. Contractor shall notify the Architect/Engineer five business days prior to pressurizing ductwork for testing.

B. Interior Duct - 3" WG and Above (positive or negative):

1. A minimum of 25% of interior ductwork (inside the building envelope) shall be tested. The Owner or designated representative shall select the sections to be tested. If duct has outside wrap, testing shall be done before it is applied.
2. Leak test shall be at the Contractor's expense and shall require capping and sealing all openings.
3. Seal ducts to bring the air leakage into compliance.
4. Contractor shall notify the Architect/Engineer five business days prior to pressurizing ductwork for testing.

C. Test Procedure:

1. Testing shall be as listed in the latest edition of the SMACNA HVAC Duct Leakage Manual, with the following additional requirements:

a. The required leakage class for Seal Class A, rectangular ducts, shall be 4; round shall be 2.
b. Test pressure shall be the specified duct pressure class. Testing at reduced pressures and converting the results mathematically is not acceptable. This is required to test the structural integrity of the duct system.

c. If any leak causes discernible noise at a distance of 3 feet, that leak shall be eliminated, regardless of whether that section of duct passed the leakage test.
d. All joints shall be felt by hand, and all discernible leaks shall be sealed.
e. Totaling leakage from several tested sections and comparing them to the allowable leakage for the entire system is not acceptable. Each section must pass the test individually.
f. Contractor shall notify the Architect/Engineer five business days prior to pressurizing ductwork for testing. Failure to notify the Architect/Engineer of pressure testing may require the contractor to repeat the duct pressure test after proper notification.
g. Upon completion of the pressure test, the contractor shall submit an air duct leakage test summary report as outlined in the SMACNA HVAC Duct Leakage Test Manual.
h. All access doors, taps to terminal air boxes, and other accessories and penetrations must be installed prior to testing. Including terminal air boxes in the test is not required.
i. Positive pressure leakage testing is acceptable for negative pressure ductwork.

D. Fume Exhaust Duct:

1. Testing shall be done before any exterior insulation is applied.
2. Cap each exhaust system at all inlets and at the discharge to atmosphere. Fans, dampers and flexible connections shall be included in the testing.
3. Pressurize each duct system to 7" water column. Leakage shall not exceed 4 cfm regardless of system size.
4. Where several fans discharge into a large collection duct, the collection duct and each individual exhaust duct may be treated as separate systems.

3.5 DUCTWORK PENETRATIONS

A. All duct penetrations of firewalls shall have fire or fire/smoke dampers where required by code.

B. Dampers shall be compatible with fire rating of wall assembly. Verify actual rating of any wall being penetrated with Architect/Engineer.

C. Seal all duct penetrations of walls that are not fire rated by caulking or packing with fiberglass. Install trim strip to cover vacant space and raw construction edges of all openings in finished rooms. Install escutcheon ring at all round duct openings in finished rooms. Trim strips and rings shall be same material and finish as exposed duct.

3.6 ACOUSTICAL LAGGING

A. Where indicated on drawings, completely wrap ductwork with lagging and seal all joints airtight with tape recommended by the lagging manufacturer to prevent acoustical leakage at joints. Overlap lagging 2" at any wall, floor, or structural deck penetration to prevent acoustical leakage.

3.7 PAINTING

A. Paint interior of ducts black within twice the largest duct dimension of inlets and outlets where interior of duct is visible.

B. Paint bottom of ducts black within twice the largest duct dimension where a duct is routed above an unducted perforated grille and the duct is visible.

END OF SECTION 23 31 00

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SECTION 23 33 00 - DUCTWORK ACCESSORIES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Manual Volume Dampers.

B. Fire Dampers.

C. Fire/Smoke Dampers.

D. Smoke Dampers.

E. Backdraft Dampers.

F. Fabric Connectors.

G. Drip Pans.

H. Duct Access Doors.

I. Duct Access Sleeve.

J. Duct Test Holes.

K. Duct Silencers.

L. Temperature Control Dampers.

1.2 SUBMITTALS

A. Submit shop drawings under provisions of Section 23 05 00.

B. Submit manufacturer's installation instructions.

C. Submit certification that ductwork accessories will withstand seismic forces defined in Section 23 05 50. Include the following:

1. Basis for Certification: Indicate whether certification is based on actual test of assembled components or on calculation.

   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

PART 2 - PRODUCTS

2.1 MANUAL VOLUME DAMPERS

A. Fabricate in accordance with SMACNA Duct Construction Standards, and as indicated.

B. Fabricate single blade dampers for duct sizes to 9-1/2 x 30 inches.

C. Fabricate multi-blade damper of opposed blade pattern with maximum blade sizes 12" x 72". Assemble center and edge crimped blades in prime coated or galvanized channel frame with suitable hardware.

D. Except in round ductwork 12 inches and smaller, provide end bearings. On multiple blade dampers, provide molded synthetic or oil-impregnated nylon or sintered bronze bearings.

E. Provide locking quadrant regulators on single and multi-blade dampers.

F. On insulated ducts, mount quadrant regulators on stand-off mounting brackets, bases, or adapters.

G. If blades are in open position and extend into the main duct, mount damper so blades are parallel to airflow.

2.2 DYNAMIC CURTAIN BLADE FIRE DAMPERS (FD)

A. Furnish and install fire dampers in ducts, where shown on the drawings, at the point where they pass through a fire wall or a floor and in all other locations required by the local fire department, The National Fire Protection Association's Pamphlet No. 90A and all other applicable codes.

B. Fire dampers shall be UL 555 listed for 1-1/2-hour fire resistance unless noted otherwise, dynamic rated with heated airflow at 2,000 fpm and 4" WC, and have all blades stacked out of the airstream (Type B).

C. Where dampers are in aluminum or stainless steel duct, provide stainless steel dampers.

D. Fire dampers shall be held open by a fusible link rated at 165°F unless otherwise called for on the drawings or by local codes.

E. Dampers shall be installed in sleeves of sufficient thickness to comply with the UL555 Standard for Safety Fire Dampers listing of the damper. Where UL555 permits sleeve thickness to be the same as that of the duct gauge, such thickness shall not be less than that specified in NFPA 90A for breakaway style sleeves. If a breakaway style duct/sleeve connection is not used, the sleeve shall be a minimum of 16 gauge for dampers up to 36" wide by 24" high and 14 gauge for dampers exceeding 36" wide by 24" high. Damper sleeve shall not extend more than 6" beyond the firewall or partition unless damper is equipped with a factory installed access door. Sleeve may extend up to 16" beyond the firewall or partition on sides equipped with the factory installed access door.

F. Maximum Curtain Damper Size (Multi-section) at less than 2,000 fpm:

1. Vertical Installation: 72"w x 48"h or 48"w x 72"h or 120"w x 24"h.
2. Horizontal Installation: 36"w x 48"h or 48"w x 36"h.

G. Maximum Curtain Damper Size at greater than 2,000 fpm: Vertical or horizontal - 24"w x 24"h.

H. Locate access door in the ductwork for visual inspection and on the latch side to replace link easily. Each access door shall have a label with letters at least 1/2" high, reading "FIRE DAMPER".

2.3 DYNAMIC MULTIPLE BLADE FIRE DAMPERS (FD)

A. General:

1. Furnish and install control/fire/smoke dampers in ducts, where shown on the drawings, at the point where they pass through a fire/smoke partition and in all other locations required by the local Fire Department, the National Fire Protection Association Pamphlet No. 90A, and all other applicable codes.
2. Fire Resistance Rating: Assemblies shall be 1-1/2 hour rated under UL Standard 555 unless noted otherwise on drawings.
3. Airflow Rating: Dynamic rated at 2,000 fpm and 4" WC.
4. Temperature Rating: Assemblies shall be UL 555S listed for use in smoke control system with a 350°F temperature rating.
5. Leakage Rating: Class II. Shall not leak over 20 cfm per square foot at 4" WC (Class II).
6. Where dampers are in aluminum or stainless steel duct, provide stainless steel dampers.

B. Construction:

1. Frame: 5 inches x minimum 16 gauge roll formed, galvanized steel hat-shaped channel, reinforced at corners.
2. Sleeve: Dampers shall be installed in sleeves of sufficient thickness to comply with UL555 Standard for Safety Fire Dampers listing of the damper. Where UL555 permits sleeve thickness to be the same as that of the duct gauge, such thickness shall not be less than that specified in NFPA 90A for breakaway style sleeves. If a breakaway style duct/sleeve connection is not used, the sleeve shall be a minimum of 16 gauge for dampers up to 36" wide by 24" high and 14 gauge for dampers exceeding 36" wide by 24" high. Damper sleeve shall not extend more than 6" beyond the firewall or partition unless damper is equipped with an actuator or factory installed access door. Sleeve may extend up to 16" beyond the firewall or partition on sides equipped with the actuator or factory installed access door.
3. Blades: Opposed blade; airfoil-shaped, single piece, minimum 14 gauge double skin. Galvanized steel. Maximum 6" damper blades.
4. Seals: Blade seal shall be silicone fiberglass material to maintain smoke leakage rating to minimum of 450°F and galvanized steel for flame seal to 1,900°F. Seal to be mechanically attached to blade edge. Jam seal shall be stainless steel, flexible metal compression type.
5. Bearings: Self-lubricating stainless-steel sleeve, in extruded hole in frame.
6. Axle: Minimum 1/2" plated steel, hex shaped, mechanically attached to blade.

C. Fusible Link: Fire dampers shall be held open by a fusible link rated at 165°°F unless otherwise called for on the drawings or by local codes.

D. Maximum Multi-Blade Size (Multiple Section) at 2,000 fpm and 4" WC:

1. Vertical Installation: 120"w x 48"h or 64"w x 96"h.
2. Horizontal Installation: 120"w x 48"h or 60"w x 96"h.

E. Access Door: Locate access door in the ductwork for visual inspection and on the latch side to replace link easily. Each access door shall have a label with letters at least 1/2" high, reading "FIRE DAMPER".

2.4 FIRE/SMOKE DAMPERS (FSD)

A. General:

1. Furnish and install fire/smoke dampers in ducts, where shown on the drawings, at the point where they pass through a fire/smoke partition and in all other locations required by the local Fire Department, the National Fire Protection Association Pamphlet No. 90A, and all other applicable codes.
2. Fire Resistance Rating: Assemblies shall be 1-1/2 hour rated under UL Standard 555 unless noted otherwise on drawings.
3. Airflow Rating: Dynamic rated at 2,000 fpm and 4" WC.

4. Temperature Rating: Assemblies shall be UL 555S listed for use in smoke control system with a 250°F temperature rating.
5. Leakage Rating: Class II. Shall not leak over 20 cfm per square foot at 4" WC.
6. FSD dampers shall be furnished complete with factory-mounted actuators, and the damper/operator assemblies shall meet all requirements listed below.
7. Where dampers are located in aluminum or stainless steel duct, provide stainless steel dampers.
8. The complete assembly must be factory assembled, cycled and tested prior to shipment.
9. All operators shall be located with easy access for servicing.
10. Contractor to field verify actuator installation and clearance requirements prior to ordering. Actuator should not be taller than duct height. Rotate or turn over the actuator if this is the case.

B. Construction:

1. Frame: 5 inches x minimum 16 gauge roll formed, galvanized steel hat-shaped channel, reinforced at corners.
2. Sleeve: Dampers shall be installed in sleeves of sufficient thickness to comply with UL555 Standard for Safety Fire Dampers listing of the damper. Where UL555 permits sleeve thickness to be the same as that of the duct gauge, such thickness shall not be less than that specified in NFPA 90A for breakaway style sleeves. If a breakaway style duct/sleeve connection is not used, the sleeve shall be a minimum of 16 gauge for dampers up to 36" wide by 24" high and 14 gauge for dampers exceeding 36" wide by 24" high. Damper sleeve shall not extend more than 6" beyond the firewall or partition unless damper is equipped with an actuator or factory installed access door. Sleeve may extend up to 16" beyond the firewall or partition on sides equipped with the actuator or factory installed access door.
3. Blades: Opposed blade; airfoil-shaped, single piece, minimum 14 gauge double skin. Galvanized steel. Maximum 6" damper blades.
4. Seals: Blade seal shall be silicone fiberglass material to maintain smoke leakage rating to minimum of 450°F and galvanized steel for flame seal to 1,900°F. Seal to be mechanically attached to blade edge. Jam seal shall be stainless steel, flexible metal compression type.
5. Bearings: Self-lubricating stainless-steel sleeve, in extruded hole in frame.
6. Axle: Minimum 1/2" plated steel, hex shaped, mechanically attached to blade.

C. Fusible Link: Fire dampers shall be held open by a fusible link rated at 165°°F unless otherwise called for on the drawings or by local codes.

D. Electric Actuator: Externally mounted, electric direct coupled. Actuator shall be 24VAC. Wiring by Mechanical Contractor. "Stall type" actuators are NOT acceptable. Actuator shall carry a manufacturer’s 5 year warranty. Fail to closed position.

E. Access Door: Locate access door in ductwork for visual inspection and on the latch side to replace link easily. Each access door shall have a label with letters at least 1/2" high reading "FIRE/SMOKE DAMPER".

2.5 SMOKE DAMPER (SD)

A. General:

1. Furnish and install smoke dampers in ducts, where shown on the drawings, at the point where they pass through a fire/smoke partition and in all other locations required by the local Fire Department, the National Fire Protection Association Pamphlet No. 90A, and all other applicable codes.
2. Fire Resistance Rating: Assemblies shall be 1-1/2 hour rated under UL Standard 555 unless noted otherwise.
3. Airflow Rating: Dynamic rated at 2,000 fpm and 4" WC.
4. Temperature Rating: Assemblies shall be UL 555S listed for use in smoke control system with a 350° temperature rating.
5. Leakage Rating: Class II. Shall not leak over 20 cfm per square foot at 4" WC.
6. SD dampers shall be furnished complete with factory mounted actuators and the damper/operator assemblies shall meet all requirements listed below.
7. Where dampers are located in aluminum or stainless steel duct, provide stainless steel dampers.
8. The complete assembly must be factory assembled, cycled and tested prior to shipment.

9. All operators shall be located with easy access for servicing.
10. Contractor to field verify actuator installation and clearance requirements prior to ordering. Actuator should not be taller than duct height. Rotate or turn over the actuator if this is the case.

B. Construction:

1. Frame: 5 inches x minimum 16 gauge roll formed, galvanized steel hat-shaped channel, reinforced at corners.
2. Sleeve: Dampers shall be installed in sleeves of sufficient thickness to comply with UL555 Standard for Safety Fire Dampers listing of the damper. Where UL555 permits sleeve thickness to be the same as that of the duct gauge, such thickness shall not be less than that specified in NFPA 90A for breakaway style sleeves. If a breakaway style duct/sleeve connection is not used, the sleeve shall be a minimum of 16 gauge for dampers up to 36" wide by 24" high and 14 gauge for dampers exceeding 36" wide by 24" high. Damper sleeve shall not extend more than 6" beyond the firewall or partition unless damper is equipped with an actuator or factory installed access door. Sleeve may extend up to 16" beyond the firewall or partition on sides equipped with the actuator or factory installed access door.
3. Blades: Opposed blade; airfoil-shaped, single piece, minimum 14 gauge double skin. Galvanized steel. Maximum 6" damper blades.
4. Seals: Blade seal shall be silicone fiberglass material to maintain smoke leakage rating to minimum of 450°F and galvanized steel for flame seal to 1,900°F. Seal to be mechanically attached to blade edge. Jam seal shall be stainless steel, flexible metal compression type.
5. Bearings: Self-lubricating stainless-steel sleeve, in extruded hole in frame.
6. Axle: Minimum 1/2" plated steel, hex shaped, mechanically attached to blade.

C. Electric Actuator: Externally mounted, electric direct coupled. Actuator shall be 24VAC. Wiring by Mechanical Contractor. "Stall type" actuators are NOT acceptable. Actuator shall carry a manufacturer’s 5 year warranty. Fail to closed position.

D. Access Door: Locate access door in ductwork for visual inspection and on the latch side to replace link easily. Each access door shall have a label with letters at least 1/2" high reading "SMOKE DAMPER".

2.6 BACKDRAFT DAMPERS

A. Gravity backdraft dampers, size 18 inches x 18 inches or smaller, furnished with air moving equipment, may be air moving equipment manufacturer's standard construction.

B. Fabricate multi-blade, parallel action gravity balanced backdraft dampers of extruded aluminum, with blades of maximum 6 inch width, with felt or flexible vinyl sealed edges, linked together in rattle-free manner with 90° stop, and plated steel pivot pin; adjustment device to permit setting for varying differential static pressure.

C. Models:

1. Ruskin CBD4
2. Arrow 655
3. Safe-Air/Dowco BRL
4. Greenheck EM.

2.7 FABRIC CONNECTORS

A. Fabric connectors shall be installed between all fans or fan units and metal ducts or casings to prevent transfer of fan or motor vibration.

B. The fabric connectors shall be completely flexible material which shall be in folds and not drawn tight.

C. Fabric connectors shall be of glass fabric double coated with neoprene, with UL approval. Weight = 30 oz. per square yard minimum. Fabric shall not be affected by mildew and shall be absolutely waterproof, airtight and resistant to acids, alkalis, grease and gasoline, and shall be noncombustible.

D. Fabric connections shall not exceed 6" in length on ductwork that has a positive pressure. On ductwork that has a negative pressure, the length shall not exceed 2" in length.

E. All corners shall be folded, sealed with mastic and stapled on 1" centers.

F. Fabric connectors shall not be painted.

G. Unless otherwise shown on the drawings, the fabric connection at the inlet to centrifugal fans shall be at least one duct diameter from the fan to prevent inlet turbulence.

H. Materials:

1. Durodyne MFN-4-100
2. Vent Fabrics, Inc.
3. "Ventglas"
4. Proflex PFC3NGA

I. Fabric connectors exposed to sunlight and weather shall be as described above, except the coating shall be hypalon in lieu of neoprene.

J. Materials:

1. Durodyne "Duralon MFD-4-100"
2. Vent Fabrics, Inc.
3. "Ventlon"
4. Proflex PFC3HGA

2.8 DRIP PANS

A. Install drip pans under all rooftop exhaust fans, intake hoods, exhaust hoods and other roof penetrations that do not have ductwork below them to intercept dripping water.

B. Drip pans shall be 22 gauge minimum cross-broken or reinforced sheet metal with 2" welded upturned lips.

C. Pans shall extend 6" in all directions beyond the opening and shall have the top of the lip located 25% of the maximum throat dimension below the opening.

D. Insulate interior of drip pan with 1" thick elastomeric foam insulation. Adhere foam to drip pan with standard foam adhesive.

2.9 DUCT ACCESS DOORS

A. Fabricate per Fig. 7-2 and 7-3 of the SMACNA HVAC Duct Construction Standards and as indicated.

B. Review locations prior to fabrication. Install access doors at fire dampers, smoke dampers, motorized dampers, fan bearings, filters, automatic controls, humidifiers, louvers, duct coils and other equipment requiring service inside the duct.

C. Construction shall be suitable for the pressure class of the duct. Fabricate rigid, airtight, and close-fitting doors of materials identical to adjacent ductwork with sealing gaskets butt or piano hinges, and quick fastening locking devices. For insulated ductwork, install minimum one inch thick insulation with sheet metal cover.

D. Access doors with sheet metal screw fasteners are not acceptable.

E. Minimum size for access doors shall be 24" x 16" or full duct size, whichever is less.

F. Provide duct access door in all horizontal return ductwork at 20 foot intervals per NFPA 90A.

G. Fire Damper, Fire/Smoke Damper Access Provide quantity of access doors such that two hands can fit inside ductwork to manually reset fire dampers. For ducts larger than 12x12 , provide one access door. For ducts 12" x 12" and smaller, provide one access door on bottom and one on side.

2.10 DUCT ACCESS SLEEVE

A. Material: Galvanized G-90 ASTM A527 Access Section. 26 gauge galvanized 12" long constructed with Pittsburgh lock seam. Access section shall be suitable for ductwork pressure class and manufactured to maintain 100 percent of ductwork free area with a clamping type draw latch.

B. Leakage: Maximum of 1/2 CFM @ 2" W.G.

C. Flange Connection: 18 gauge galvanized. Clamps: 20 gauge galvanized with zinc coated draw latch.

D. Gasket: Neoprene gasket 3/16" x 1-1/4", gasket profile forms to the inside of the clamp and seals the outer edges of the access section 18 gauge flanges. Seal seams in accordance with SMACNA HVAC Duct Construction Standard – Metal and Flexible.

E. Insulation: Contractor shall insulate in field per Duct Insulation Schedule. Include removable wrap around flanges. Manufacturer shall provide duct liner in systems as defined in Duct Insulation Schedule.

F. Locations: Install duct access sleeve in the following locations:

1. Fire Dampers, Fire Smoke Dampers and Smoke Dampers: Provide duct access sleeve at dampers 12" x 12" and 12" diameter and smaller not more than 4" away from the fire damper sleeve.
2.

G. Manufacturers:

1. Langdon, Inc. Sure Clamp

2.11 DUCT TEST HOLES

A. Cut or drill temporary test holes in ducts as required. Cap with neat patches, neoprene plugs, threaded plugs, or threaded or twist-on metal caps.

2.12 DUCT SILENCERS

A. Straight Silencer

1. All silencers shall be factory fabricated by the same manufacturer, except that 'No-Loss" silencers (thicker than normal double-wall ducts) may be Contractor fabricated.
2. Duct silencers shall have length, air pressure drop, and self-generated sound ratings not to exceed the values scheduled on the drawings. Dynamic insertion ratings shall not be less than those scheduled on the drawings. Silencer inlet and outlet dimensions must match the sizes on the drawings. Transitions are not acceptable unless shown on the drawings.
3. All silencer ratings shall be determined in accordance with the ASTM E477-06a test standard. The test set-up, procedure and facility shall eliminate all effects due to flanking, directivity, end reflection, standing waves and reverberation room absorption.

4. Silencers shall be constructed of galvanized steel, have 26 gauge minimum perforated interior (22 gauge for transitional silencers), be able to withstand 8" of positive and 4" of negative pressure, and shall have inorganic, bacteria, and fungus resistant glass fiber filler with not less than 5% compression. Silencers shall meet SMACNA standards for the duct pressure class specified.
5. Fiberglass cloth or other scheduled liners shall completely separate the media from the airstream. No-media silencers shall not contain absorptive packing of any kind.
6. Silencers shall not exceed 25/50 flame spread/smoke developed per ASTM E84, NFPA 255, or UL 723.
7. Manufacturers:

   a. Vibro-Acoustics
   b. VAW
   c. United McGill
   d. Semco
   e. Ruskin Sound Control (Rink)
   f. Dynasonics
   g. Price
   h. All silencers shall be by the same manufacturer

B. Elbow Silencer:

1. All silencers shall be factory fabricated by the same manufacturer, except that 'No-Loss" silencers (thicker than normal double-wall ducts) may be Contractor fabricated.
2. Duct silencers shall have length, air pressure drop, and self-generated sound ratings not to exceed the values scheduled on the drawings. Dynamic insertion ratings shall not be less than those scheduled on the drawings. Silencer inlet and outlet dimensions must match the sizes on the drawings. Transitions are not acceptable unless shown on the drawings
3. All silencer ratings shall be determined in accordance with the ASTM E477-06a test standard. The test set-up, procedure and facility shall eliminate all effects due to flanking, directivity, end reflection, standing waves and reverberation room absorption.
4. Silencers shall be constructed of galvanized steel with an 18 gauge galvanized steel outer casing and 22 gauge galvanized perforated steel. All acoustical splitters shall be internally radiused and aerodynamically designed for efficient turning of the air. Half and full splitters are required as necessary to achieve the scheduled insertion loss. All elbow silencers with a turning cross-section dimension greater than 48 shall have at least two half splitters and one full splitter. Silencers shall be able to withstand 8" of positive and 4" of negative pressure, and shall have inorganic, bacteria, and fungus resistant glass fiber filler with not less than 5% compression. Silencers shall meet SMACNA standards for the duct pressure class specified.
5. Fiberglass cloth or other scheduled liners shall completely separate the media from the airstream. No-media silencers shall not contain absorptive packing of any kind.
6. Silencers shall not exceed 25/50 flame spread/smoke developed per ASTM E84, NFPA 255, or UL 723.
7. Manufacturers:

   a. Vibro-Acoustics
   b. VAW
   c. United McGill
   d. Semco
   e. Ruskin Sound Control (Rink)
   f. Dynasonics
   g. Price
   h. All silencers shall be by the same manufacturer.

2.13 REMOTE VOLUME CONTROL DEVICES - MANUAL

A. Remote volume control balancing damper shall be supplied with either miter gears or right angle worm gears. Provide all damper shafts, gearboxes, couplings, U-joints, bearings, shafts, offsets, adapters, and adjustable concealed covers as required.

B. When distances, angles, or offsets prevent installing solid rods, the mechanical cable control system may be utilized. Provide all damper shafts, rack and pinion gear operator, cables and sleeves, and adjustable ceiling mounting cups.

C. Manufacturers:

1. Young Regulator Company
2. Metropolitan Air Technology

2.14 DUCTWORK ACCESSORY SEALANTS

A. Ductwork accessory sealants and adhesives shall conform to Section 23 31 00.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General Installation Requirements:

1. Install accessories in accordance with manufacturer's instructions.
2. Where duct access doors are located above inaccessible ceilings, provide ceiling access doors. Coordinate location with the Architect/Engineer.
3. Coordinate and install access doors provided by others.
4. Provide access doors for all equipment requiring maintenance or adjustment above an inaccessible ceiling. Minimum size shall be 24" x 24".
5. Grease duct access doors shall be installed per approvals from manufacturer's ICC-ES Evaluation Report.
6. Provide duct test holes where indicated and as required for testing and balancing purposes.

B. Manual Volume Damper:

1. Provide manual volume dampers at points on low pressure supply, return, and exhaust systems where branches are taken from larger ducts where indicated on drawings and as required for air balancing. Use splitter dampers only where indicated.
2. Provide ceiling access doors for manual volume dampers. When manual volume dampers are located above an inaccessible ceiling and an access door cannot be installed, provide a remote-controlled volume control device for operation of the damper. Coordinate location with the Architect/Engineer.
3. Grease duct volume dampers shall be continuously welded to duct and/or hoods so that system is liquidtight.

C. Fire Damper, Fire Smoke Damper, Smoke Damper:

1. Provide fire dampers, combination fire and smoke dampers, and smoke dampers 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 and duct connections.
2. Provide ceiling access doors for smoke and/or fire dampers. Coordinate location with the Architect/Engineer.
3. Demonstrate resetting of fire dampers to authorities having jurisdiction and Owner's representative.
4. At fire dampers, smoke dampers and combination fire smoke damper where duct is:

   a. Internally insulated, exterior duct wrap shall be installed from the wall out to 1 foot from the wall. All edges shall be taped.
   b. Externally insulated, the exterior duct wrap shall extend up to the wall.

D. Drain Pan:

1. Drain pans shall be installed per ASHRAE 62.1.

a. All drain pans shall be field tested under normal operating conditions to ensure proper drainage.
b. Field testing of drain pans is not required if units with factory installed drain pans have been certified (attested in writing) by the manufacturer for proper operation when installed as recommended.

E. Control Dampers and Damper Actuators:

1. Install control dampers and damper actuators in accordance with manufacturer's instructions and in coordination with the Temperature Control Contractor.
2. Seal around damper frame inside ductwork with duct sealant to prevent bypass around damper.
3. Provide duct access door at each control damper.

END OF SECTION 23 33 00

SECTION 23 34 13.13 - MIXED FLOW LABORATORY EXHAUST FANS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Mixed Flow Fans.

1.2 QUALITY ASSURANCE

A. Performance Ratings: Bear the AMCA Certified Rating Seal - Air Performance and Sound Performance.

B. Fabrication: Conform to AMCA 99.

C. Fan Energy Index (FEI): Fans shall meet or exceed the minimum FEI scheduled at the specified airflow, pressure, and air density (duty point). In no case shall the FEI at the specified duty point fall below 1.0.

1.3 SUBMITTALS

A. Submit shop drawings per Section 23 05 00. Include data on all fans and accessories. Submit sound power levels for both fan inlet and outlet at rated capacity. Submit motor ratings and electrical characteristics, plus motor and electrical accessories. Submit multi-speed fan curves including minimum and maximum fan speed with specified operating points clearly plotted. Submit the Fan Energy Index (FEI) at the selected duty point.

B. Submit details on the corrosion resistant coating.

C. Submit motor data indicating compliance with Section 23 05 13.

D. Submit operation and maintenance data. Include instructions for lubrication, motor and drive replacement and spare parts list.

E. Submit dimensional drawings and product data for each laboratory exhaust fan assembly.

F. Submit nozzle velocity of exhaust fans, total exhaust flow per AMCA 260, and discharge plume rise at specified wind velocity.

G. Submit certification that axial fans, accessories, and components will withstand seismic forces defined in Section 23 05 50. Include the following:

1. Basis for Certification: Indicate whether certification is based on actual test of assembled components or on calculation.

    a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Protect motors, shafts, and bearings from weather and construction dust.

1.5 WARRANTY

A. Provide five-year warranty covering materials and labor cost for repair for the entire exhaust fan assembly.

PART 2 - PRODUCTS

2.1 LABORATORY EXHAUST FANS - MIXED FLOW INDUCED DILUTION TYPE

A. Direct Drive:

1. Impellers shall be mounted directly to the motor shaft to provide a direct drive arrangement 4 type fan or arrangement 2 type fan. Motors shall be isolated from the primary exhaust airstream and shall be visible and accessible from the fan exterior for inspection and service.
2. Manufacturers:

a. Strobic Air - Tri-Stack
b. Greenheck Vektor MD
c. Loren Cook QMX-DVP

B. Mixed flow impellers shall consist of combination axial/backward curved blades and shall be of welded steel construction. The impellers shall have non-stall and non-overloading characteristics with stable operation at any point on the fan curves.

C. Stationary discharge guide vane sections shall be provided to increase fan efficiencies.

D. Dynamically balance to Level BV-3 per AMCA 204.

Fan Application Category	Application	Rigidly Mounted (in/sec)	Flexibly Mounted (in/sec)
BV-1	Residential	0.50	0.60
BV-2	Residential, HVAC & Agriculture	0.20	0.30
BV-3	Industrial Process and Power Generation, Transportation, Marine, Transit/Tunnel, Petrochemical process	0.15	0.20
BV-4	Industrial Process and Power Generation, Transportation, Marine, Transit/Tunnel, Petrochemical process	0.10	0.15
BV-5	Computer Chip Manufacture	0.08	0.10

E. Fan assemblies shall be designed for mounting on conventional roof curb without the need for guy wire supports.

F. Fan and all drive components shall have a minimum bearing life of L_{10} = 100,000 hours.

G. Fan shall be constructed to AMCA "C" standards with a nonferrous inlet bell provided to reduce sparking in the event of a motor bearing failure.

H. Fan and mixing box systems supplied by the manufacturer must have a footprint as shown on the drawings / schedule. Exhaust systems with larger footprints are not acceptable.

I. Maintenance shall only be required on a minimum of 18-month intervals. This maintenance shall be limited to re-greasing of the motor bearings.

J. Entrainment wind bands shall provide secondary induction of outside air. Induction shall take place downstream of the fan impeller and shall not influence BHP or static pressure requirements. Wind bands shall discharge at least 25 % of design flow rates. The manufacturer shall publish discharge volumes for all fans at specified exhaust flow.

K. Fans shall be modular construction and capable of being assembled on the roof.

L. PTFE gaskets shall be provided at all companion flanged joints.

M. Fasteners shall be 316 stainless steel.

N. A bolted access door shall be provided for impeller inspection on each fan.

O. Fans and accessories shall have internal drain systems to prevent rain water from entering building duct system.

P. Electric motors shall be TEFC Mill & Chemical duty with a 1.15 service factor. Motors shall meet performance and shaft grounding requirements of Section 23 05 13.

Q. A NEMA 3R non-fused disconnect switch shall be provided, mounted and wired to the motor.

R. Coating: All steel and aluminum surfaces shall be prepared for coating by blasting or chemical etching. Coating shall be 6 to 10 mils thick for protection against weather, chemical vapors and splashes.

S. Custom Inlet Mixing Plenum:

1. Inlet mixing plenums shall be provided by the fan manufacturer. Each plenum shall be sized to support the weight and performance requirements of the number of fans listed on the schedule. Multiple fan plenums shall be double wall construction with structural stiffeners or shall be continuously welded. All plenums shall be capable of supporting the fan(s) without guy wires or supports. The plenums shall include hinged access doors and safety screens over primary air inlets. The primary air inlets shall be located on the bottom or side as noted on construction drawings. Coatings shall be the same as specified for the fans. Unless otherwise specified, plenums shall be suitable for mounting on roof curbs.
2. Bypass dampers shall be provided with plenums for mixing outside air with primary exhaust. Refer to Section 23 09 00 damper requirements.

    a. Bypass dampers shall be provided custom mounted on the side of the plenum.
    b. Bypass dampers shall be sized for VAV operation. Refer to drawings for maximum bypass flow rate.
    c. Bypass dampers shall be controlled by 24V electric operators.

3. Plenums shall be provided with a jib crane mounting bracket. Provide 1 jib crane with the plenum.
4. Plenum box shall be capable of fitting 4 fans total on day one. Only 3 fans will be installed but provisions should be made for the 4th fan to attach in the future. Provide isolation damper and cap for 4th fan position.
5. Plenum box shall be sized for a 4x1 fan array.

T. Extended motor lube lines of PTFE tubing covered with braided stainless steel shall be provided. Extended lube lines shall be mounted to a bracket located on the fan housing, with grease relief fittings on each line.

U. The static pressure shown in the schedule is based on the static pressure requirements at the inlet to the mixing box and does not include any losses of equipment provided by the fan manufacturer. All losses for the equipment provided by the fan manufacturer shall be detailed in the fan manufacturer's submittal.

V. Low leakage isolation dampers shall be constructed of aluminum airfoil extrusions and shall have a chemical resistant coating (6 to 10 mils). Operators shall be 2-position, spring return and shall be 24V electric. Electric operators shall be factory wired (via a transformer when required) to the fan disconnect switch to open when the fan is energized and close via a spring return when de-energized. When the fan ships separate from the plenum, all wiring and conduit shall be factory supplied for easy connection in the field.

W. Vortex breakers shall be provided on all side-inlet and multiple fan plenums.

X. Acoustical silencer nozzle shall be designed as an integral component of the exhaust fan discharge nozzle and shall not increase the height of the overall assembly.

1. The maximum air pressure drop shall be 0.1" W.C. when installed, and all associated losses shall be included in the fan performance curve.
2. The silencer shall be constructed with an outer shell of fiber reinforced plastic with a minimum of 3/16" wall thickness. The inner liner shall be perforated corrosion resistant steel. The silencer shall be colored to match the fans. Acoustic media shall be 3 LB/CF density fiberglass isolated from the airstream by a Tedlar film, non-fibrous acoustical media.

Y. Roof Mounting Curb: Minimum 14 inches (mm), minimum 14 gauge galvanized steel, one-piece construction, insulated, all welded, wood nailer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Do not operate fans for any purpose until bearings are lubricated and fans have been test run under observation.

END OF SECTION 23 34 13.13

SECTION 23 34 16 - CENTRIFUGAL FANS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Fume Exhaust Fans.

B. Performance Ratings: Bear the AMCA Certified Rating Seal - Air Performance.

C. Fabrication: Conform to AMCA 99.

D. Fan Energy Index (FEI): Fans shall meet or exceed the minimum FEI scheduled at the specified airflow, pressure, and air density (duty point). In no case shall the FEI at the specified duty point fall below 1.0.

1.2 SUBMITTALS

A. Submit shop drawings per Section 23 05 00. Include data on all fans and accessories. Submit sound power levels for both fan inlet and outlet at rated capacity. Submit motor ratings and electrical characteristics, plus motor and electrical accessories. Submit multi-speed fan curves including minimum and maximum fan speed with specified operating points clearly plotted. Submit the Fan Energy Index (FEI) at the selected duty point.

B. Submit operation and maintenance data. Include instructions for lubrication, motor and drive replacement, and spare parts list.

C. Submit certification that centrifugal fans, accessories, and components will withstand seismic forces defined in Section 23 05 50. Include the following:

1. Basis for Certification: Indicate whether certification is based on actual test of assembled components or on calculation.

    a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.3 EXTRA STOCK

A. Provide one extra belt set for each fan unit.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Protect motors, shafts, and bearings from weather and construction dust.

PART 2 - PRODUCTS

2.1 ROOF-MOUNTED FUME/ISOLATION FAN ASSEMBLY

A. Single inlet, single width. backward inclined wheel, with factory stack extension, factory mounted inlet box, mounted to a single curb cab.

B. Direct Drive Arrangement 4. Motor per the drawings and Section 23 05 13.

C. Fan/Duct Construction: Steel or aluminum construction with baked enamel finish. Fan serving the hydrofluoric acid hoods in geology shall be hydrofluoric acid resistant. Duct connections shall be polypropylene.

D. Suitable for ambient temperatures from -40°F to +120°F. Wind rated for 115mph.

E. Fan Bearings: Regreasable, rated for 40,000 hour B-10 life at specified operating point.

F. Furnish factory mounted and wired disconnect switch, non-fusible type with thermal overload protection.

G. Roof Mounting Curb: Minimum 18 inches, minimum 14 gauge galvanized steel, one-piece construction, insulated, all welded, wood nailer.

H. Curb Cap and Inlet Box: Fully welded seams and corners, gasketed access door, and under curb duct drop with matching flange and field duct connection.

I. Stack Extension: Integral, self-supported stack for a minimum of 10ft discharge above the roof.

J. Manufacturers:

1. Greenheck FJ
2. Cook CPS

2.2 FUME EXHAUST FAN (300-20,000 cfm AND 0-8" STATIC PRESSURE)

A. Single inlet, single width.

B. Arrangement 10 with motor below shaft.

C. Heavy gauge steel all welded construction (14 gauge min. sides), adaptable to any of 8 discharge positions in the field.

D. Suitable for exhaust streams from -40° to +200°F and ambient temperatures from -40° to +120°F.

E. Non-overloading horsepower characteristic. Stable performance from closed-off to wide-open at all speeds.

F. Lifting eyes.

G. 14 gauge minimum inlet collar, flanged outlet connection.

H. Belts and sheaves sized for a minimum 1.3 of motor horsepower.

I. Motor per the drawings and Section 23 05 13 "Motors".

J. AMCA Type B spark resistant construction including aluminum wheel and non-ferrous shaft closure plate.

K. Regreasable bearings rated for 100,000 hour B-10 life at specified operating point.

L. Heavy-duty gas-tight shaft seals.

M. Backward inclined airfoil wheels suitable for handling fumes and gases at minimum noise levels, or backward inclined flat blades suitable for handling particulates. Refer to drawings for type required.

N. Furnish factory mounted and wired disconnect switch, non-fusible type with thermal overload protection in a NEMA 3R enclosure.

O. All surfaces in contact with the airstream shall be cleaned with solvent equal to Heresite 330 and given three 2 mil minimum thickness coats of air dried phenolic equal to Heresite VR-500. Coat entire face of all flanges and entire length of inlet collars on both sides. Fan serving the hydrofluoric acid hoods in geology shall be hydrofluoric acid resistant. Duct connections shall be polypropylene.

P. Adjustable pitch sheaves with the specified operating point in the center of adjustment range, anti-static type belts.

Q. Positive screw-type belt tensioning mechanism.

R. Factory tested before shipment.

S. Belt guards with tachometer knockouts on indoor fans. Removable weather covers on outdoor fans.

T. 1" drain connections in housing bottoms.

U. Lever operated access door near top of scroll for wheel inspection.

V. Products:

1. Aerovent 'BI' or 'BIA'
2. Twin City 'BC'
3. Cook 'CA'

PART 3 - EXECUTION

3.1 INSTALLATION

A. General Installation Requirements:

1. Do not operate fans for any purpose until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.
2. Install flexible connections between fan and ductwork. Install metal bands of connectors parallel with minimum 1" flex between ductwork and fan while running.
3. Provide safety screen where inlet or outlet is exposed. Screens shall meet OSHA regulations for size of openings.

B. Fume Exhaust Fan:

1. Each fume exhaust fan shall have a 3/8" diameter hole drilled in one of its base rails for electrical grounding. Scrape away paint near the hole for good grounding.

END OF SECTION 23 34 16

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SECTION 23 34 23 - POWER VENTILATORS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Roof Exhaust Fan.

B. Rooftop Fan Curbs.

1.2 QUALITY ASSURANCE

A. Performance Ratings: Conform to AMCA 210 and bear AMCA Certified Rating Seal.

B. Sound Ratings: AMCA 301, tested to AMCA 300.

C. Fabrication: Conform to AMCA 99.

D. Fan Energy Index (FEI): Fans shall meet or exceed the minimum FEI scheduled at the specified airflow, pressure, and air density (duty point). In no case shall the FEI at the specified duty point fall below 1.0.

1.3 REFERENCES

A. AMCA 99 - Standards Handbook.

B. AMCA 208 - Calculation of the Fan Energy Index (FEI).

C. AMCA 210 - Laboratory Methods of Testing Fans for Rating Purposes.

D. AMCA 230 - AMCA 230 - Laboratory Methods of Testing Air Circulating Fans for Rating and Certification.

E. AMCA 300 - Test Code for Sound Rating Air Moving Devices.

F. AMCA 301 - Method of Publishing Sound Ratings for Air Moving Devices.

G. ANSI/AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings.

H. ANSI/AFBMA 11 - Load Ratings and Fatigue Life for Roller Bearings.

I. SMACNA - HVAC Duct Construction Standards, 1995 Edition.

1.4 SUBMITTALS

A. Submit shop drawings per Section 23 05 00. Include data on all fans and accessories. Submit sound power levels for both fan inlet and outlet at rated capacity. Submit motor ratings and electrical characteristics, plus motor and electrical accessories. Submit multi-speed fan curves including minimum and maximum fan speed with specified operating points clearly plotted. Submit the Fan Energy Index (FEI) at the selected duty point (ceiling and HVLS fans are exempt from FEI submittal requirements).

B. Submit manufacturer's installation instructions.

C. Submit electrical power/controls wiring diagrams and product data indicating general assembly, components, safety controls, and service connections.

D. Submit certification that power ventilators, accessories, and components will withstand seismic forces defined in Section 23 05 50. Include the following:

1. Basis for Certification: Indicate whether certification is based on actual test of assembled components or on calculation.

   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
   b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.5 EXTRA STOCK

A. Provide one (1) extra belt set for each fan unit.

PART 2 - PRODUCTS

2.1 ROOFTOP EXHAUST FAN - DIRECT DRIVEN

A. Fan Wheel: Centrifugal type, aluminum or composite with backward inclined or airfoil blades, statically and dynamically balanced.

B. Housing: Removable, spun aluminum dome or rectangular top, with square, one piece, aluminum base and curb cap with Venturi inlet cone.

C. Fan Shaft: Turned, ground and polished steel; keyed to wheel hub.

D. All steel parts galvanized or epoxy coated. Non-corrosive fasteners.

E. Direct drive, motor mounted outside of air stream and ventilated with outside air.

F. Aluminum or brass bird screen. Plastic mesh will not be allowed.

G. Furnish factory mounted and wired disconnect switch: Non-fusible type with thermal overload protection mounted inside fan housing, factory wired through an aluminum conduit.

H. Disconnect provided by Electrical Contractor.

I. Furnish solid-state dial speed controller. Mount and wire inside fan unless shown otherwise on the drawings. Provide permanent marking at balanced point.

J. Furnish normally closed, electric motorized damper. Provide step-down transformer if required. Install and wire damper to open when fan runs.

K. Dampers shall be aluminum with brass bushings, blade seals and blade tie rods. Leakage shall not exceed 4 cfm/sq.ft @1" SP (or shall be AMCA Class 1 certified).

L. Mill aluminum finish.

M. Furnish permanently lubricated sealed ball type motor and drive shaft bearings. Motor and wheel supported by vibration isolators.

N. Manufacturers:

1. Aerovent "FACX"
2. Cook "ACE-D"
3. Greenheck
4. ILG - CRD
5. ACME PX
6. PennBarry DX
7. Carnes
8. Twin City DCRU
9. Jenco
10. Soler-Palau
11. York

2.2 ROOFTOP EXHAUST FAN - VERTICAL DISCHARGE - BELT DRIVEN

A. Fan Wheel: Centrifugal type, aluminum hub and wheel with backwards inclined blades, statically and dynamically balanced.

B. Housing: Removable, spun aluminum dome or rectangular top, with square, one piece, aluminum base and curb cap with Venturi inlet cone.

C. Fan Shaft: Turned, ground and polished steel; keyed to wheel hub.

D. V-belt drive with adjustable pitch drive sheave and adjustable motor mountings for belt tensioning.

E. Motor mounted outside of air stream and ventilated with outside air. Motor not less than 1/3 HP.

F. Aluminum or brass bird screen. Plastic mesh will not be allowed.

G. Furnish factory mounted and wired disconnect switch: Non-fusible type with thermal overload protection mounted inside fan housing, factory wired through an aluminum conduit.

H. Disconnect provided by Electrical Contractor.

I. Permanently lubricated, permanently sealed, self-aligning ball bearings.

J. Furnish permanently lubricated sealed ball type motor and drive shaft bearings sized for 200,000 hours life at specified operating conditions. Drives sized for 150% of rated motor horsepower. Drive assembly and wheel supported by vibration isolators.

K. Include ventilated curb cap and hinged base with restraining means.

L. Furnish normally closed, electric motorized damper. Furnish step down transformer if required. Install and wire damper to open when fan runs.

M. All fans serving range hoods shall have extended shrouds to discharge at least 40" above roof and built-in grease trough with drain.

N. Mill aluminum finish.

O. Fan shall be UL listed for "Power Ventilators for Smoke Control Systems."

P. Manufacturers:

1. ACME
2. Cook
3. Greenheck
4. PennBarry
5. Twin City
6. Jenco
7. Soler-Palau
8. York

2.3 ROOFTOP FAN CURBS

A. Furnish and install prefabricated roof curbs for all rooftop fans.

B. Size curb to match the curb cap of fan.

C. Roof Mounting Curb: Minimum 18 inches, minimum 14 gauge galvanized steel, one-piece construction, insulated, all welded, wood nailer.

D. Unitized construction, continuous arc welded corner seams. Insulated with 1-1/2" thick, 3 lb. density rigid fiberglass board. Damper support angle. Pressure treated wood nailer.

E. If called for in the drawings, curbs shall be of the sound attenuation type. Sound attenuation curbs shall reduce the fan sone rating by at least 40% and not decrease fan cfm more than 8% (which is accounted for in the scheduled fan cfm). Baffles shall be removable for access to the dampers.

F. 18-gauge galvanized steel construction.

G. Curb without cant.

H. Manufacturers:

1. Same manufacturer as the fan
2. Pate
3. RPS
4. Thy

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Secure roof exhausters with cadmium plated lag screws to roof curb.

C. If manufacturer has no recommendations, secure roof exhaust fans to curbs with 1/4" lag bolts on 8" maximum centers.

D. MC shall install and wire factory provided damper to open when the fan runs if the manufacturer does not provide an option to pre-wire the damper.

END OF SECTION 23 34 23

SECTION 23 36 00 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Single Duct Variable Air Volume Terminal Box.

1.2 SUBMITTALS

A. Submit shop drawings under provisions of Section 23 05 00.

B. Submit shop drawings indicating configuration, general assembly, and materials used in fabrication.

C. Submit product data indicating configuration, general assembly, and materials used in fabrication. Include catalog performance ratings which indicate airflow, static pressure, and NC designation.

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. Submit electrical power/controls wiring diagrams and product data indicating general assembly, components, safety controls, and service connections.

F. Submit manufacturer's installation instructions.

G. Submit certification that all air terminal units, accessories, and components will withstand seismic forces defined in Section 23 05 50. Include the following:

1. Basis for Certification: Indicate whether certification is based on actual test of assembled components or on calculation.

   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.3 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data.

B. Include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts lists.

C. Include directions for resetting constant volume regulators.

PART 2 - PRODUCTS

2.1 ACOUSTICAL CONSIDERATIONS (THIS APPLIES TO ALL UNITS)

A. All units shall have noise data certified in accordance with AHRI Standard 885-98 with 5/8" 20-lb. density mineral fiber ceiling tile and shall not produce space noise values over NC-35 due to radiated and airborne noise combined. Acoustical considerations shall take priority over sizes noted in schedule. It is the manufacturer's responsibility to increase inlet size to meet acoustic levels scheduled. Noise in classrooms shall not exceed 35 dBA or 55 dBC per ANSI Standard S12.60-2002.

2.2 SINGLE DUCT VARIABLE AIR VOLUME TERMINAL BOX

A. 16 gauge aluminum housing with internal components of aluminum and stainless steel.

B. Nylon bushings at moving parts.

C. Venturi configuration for smooth variations in airflow.

D. Pressure independent operation without means of external monitoring devices. Box shall maintain constant volume at all flow rates regardless of changes in upstream or downstream static pressure.

E. Factory calibrate all boxes for the maximum and minimum cfm scheduled on the drawings. Settings shall be field adjustable by means of an external calibrated dial.

F. Boxes shall be gasketed for 100% shutoff capabilities, unless noted otherwise on the drawings.

G. Insulation:

1. Factory wrapped with minimum 3/8" elastomeric closed cell insulation. Insulation shall be UL listed and meet NFPA 90A requirements.

a. Usage: All supply air systems.

2. Non-insulated.

a. Usage: Return air system, exhaust air system.

H. Boxes shall have pressure independent control capable of controlling with a 0.4" to 3.0" WG pressure drop.

I. Spring ranges and/or failure positions shall be as listed on the drawings or in the Controls section of these specifications.

J. Damper Operators: Electronic. Furnish all mounting brackets, relays, and linkages. Provided and installed by the manufacturer.

1. Operator shall be UL listed, electronic direct coupled with spring return to normal position for modulating or two-position control as noted in the sequence of control. Actuator shall be 24 VAC with proportional control, electronic overload protection to prevent actuator damage due to over-rotation and "V" bolt clamp with matching "V" toothed cradle (single bolt or setscrew fasteners not acceptable).

K. Electronic Volume Regulator/Controller: Provided and installed by the manufacturer. Set boxes for maximum and minimum settings shown on the drawings.

L. Refer to control diagrams and notes on control drawings for complete sequence of control.

M. Manufacturers:

1. Johnson Controls Inc.
2. Phoenix

2.3 SINGLE DUCT VARIABLE AIR VOLUME TERMINAL BOX

A. Casing: Minimum 22 gauge galvanized steel.

1. Fully insulated with minimum 1" foil faced liner, minimum 1-1/2 pound density fiberglass insulation. Insulation shall be UL listed and meet NFPA 90A requirements.

a. Usage: All supply air systems.

2. Non-insulated.

a. Usage: Return air system, exhaust air system.

B. Damper Blade: Extruded aluminum or minimum 18 gauge galvanized steel. Nylon or bronze bushings on damper shafts. Dampers shall seal against gasketed stops. Leakage shall not exceed 4% of unit nominal cfm at 3.0 inches WG inlet static pressure.

C. Inlet Flow Sensor: Provide "cross" • or "ring• " style velocity and static sensor at inlet to box for use by unit controller.

D. Damper Operators: Electronic. Furnish all mounting brackets, relays, and linkages. Provided and installed by the TCC in the field.

1. Operator shall be UL listed, electronic direct coupled with spring return to normal position for modulating or two-position control as noted in the sequence of control. Actuator shall be 24 VAC with proportional control, electronic overload protection to prevent actuator damage due to over-rotation and "V" bolt clamp with matching "V" toothed cradle (single bolt or setscrew fasteners not acceptable).

E. Electronic Volume Regulator/Controller: Provided and installed by the TCC in the field. Boxes shall have pressure independent control to maintain constant air volume regardless of duct pressure changes up to 6 inches w.c. and shall be accurate down to 0.004" velocity pressure. Set boxes for maximum and minimum settings shown on the drawings.

F. Hot Water Coils: Copper tubes, aluminum fins, minimum 0.016" wall thickness, leak tested at 300 psig. Air pressure drop shall not exceed scheduled value. Provide access door or removable panel for access to the upstream side of the heating coil. Capacity shall be as scheduled on the drawings. Hot water control valve shall be by the TCC.

G. Boxes shall not exceed the static pressure drop and N.C. level scheduled on the drawings. It is the manufacturer's responsibility to increase inlet size to meet pressure drop and N.C. levels scheduled.

H. Refer to control diagrams and notes on control drawings for complete sequence of control.

I. Manufacturers:

1. Carrier
2. Titus
3. Trane
4. Krueger
5. Carnes
6. E.H. Price
7. Tuttle & Bailey

8. Nailor
9. Enviro-Tec
10. Johnson Controls Inc.
11. Metalaire.
12. Anemostat.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Maintain minimum working clear space for all electrical connections in accordance with NFPA 70, National Electrical Code.

C. Provide ceiling access doors or locate units above easily removable ceiling components.

D. Support units individually from structure. Do not support from adjacent ductwork.

E. Where boxes are located adjacent to a wall or joist, the damper motors and control valves shall be located on the side of the box away from the wall or joist to permit easy access.

F. Comb fins on coils to repair bent fins.

G. Insulate terminal air box hydronic reheat coils to prevent condensation. Tape insulation tight to box. Do not insulate or interfere with actuator, access panel and control panel.

3.2 ADJUSTING

A. All boxes shall be set to the cfm shown on the drawings. TCC shall be responsible to field recalibrate all boxes that are not set correctly.

END OF SECTION 23 36 00

SECTION 23 37 00 - AIR INLETS AND OUTLETS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Grilles And Registers.

B. Architectural Square Panel Diffusers.

C. Square Stepdown Cone Diffusers.

D. Laminar Flow Diffusers.

E. Linear Diffusers.

F. Linear Diffuser Supply Plenum.

G. Louvers.

H. Louvered Penthouses.

I. Roof Hoods.

J. Roof Curbs.

K. Goosenecks.

1.2 QUALITY ASSURANCE

A. Test and rate performance of air inlets and outlets per ASHRAE 70.

B. Test and rate performance of louvers per AMCA 500L-99.

C. All air handling and distribution equipment mounted outdoors shall be designed to prevent rain intrusion into the airstream when tested at design airflow and with no airflow, using the rain test apparatus described in Section 58 of UL 1995.

1.3 SUBMITTALS

A. Submit product data under provisions of Section 23 05 00.

B. Submit schedule of inlets and outlets indicating type, size, location, application, and noise level.

C. Review requirements of inlets and outlets as to size, finish, and type of mounting prior to submitting product data and schedules of inlets and outlets.

D. Submit manufacturer's installation instructions.

E. Submit electrical power/controls wiring diagrams and product data indicating general assembly, components, safety controls, and service connections.

1.4 REGULATORY REQUIREMENTS

A. Conform to ANSI/NFPA 90A.

B. Conform to ASHRAE 90.1.

1.5 EXTRA STOCK

A. Provide clean filters in all filter return grilles at time of installation.

B. Provide one additional set of replacement filters for all filter return grilles. Deliver to Owner at job site.

PART 2 - PRODUCTS

2.1 AIR TERMINALS - GRILLES AND REGISTERS

A. Reference to a grille means an air supply, exhaust or transfer device without a damper.

B. Reference to a register means an air supply, exhaust or transfer device with a damper.

C. The type of unit, margin, material, finish, etc., shall be as shown on the drawing schedule and suitable for the intended use.

D. All margins shall be compatible with ceiling types specified (including 'Thin-Line' T-bar lay-in grid system). Any discrepancies in contract documents shall be brought to the attention of the Architect/Engineer, in writing, prior to Bid Date. Submission of Bid indicates ceiling and air inlet and outlet types have been coordinated.

E. The capacity and size of the unit shall be as shown on the drawings.

F. All units shall handle the indicated cfm as shown on the drawings while not exceeding an NC level of 25, referenced to 10^{-12} watts with a 10 dB room effect. Noise in classrooms may not exceed 35 dBA or 55 dBC per ANSI Standard S12.60-2002 and ASHRAE 70.

G. Refer to the drawings for construction material, color and finish, margin style, deflection, and sizes of grilles and registers.

H. Provide with 3/4" blade spacing. Blades shall have steel friction pivots to allow for blade adjustment, plastic pivots are not acceptable.

I. Corners of steel grilles and registers shall be welded and ground smooth before painting. Aluminum grilles and registers shall have staked corners.

J. Where specified to serve registers, provide opposed blade volume dampers operable from the face of the register.

K. Screw holes for surface fasteners shall be countersunk for a neat appearance. Provide concealed fasteners for installation in lay-in ceilings and as specified on the drawings.

L. Manufacturers:

1. Tuttle & Bailey
2. Titus
3. Price
4. Nailor

5. Carnes
6. Metalaire
7. Krueger
8. Anemostat
9. Raymon Donco

2.2 AIR TERMINALS - ARCHITECTURAL SQUARE PANEL DIFFUSERS

A. Reference to a diffuser means an air supply device, ceiling mounted, that shall diffuse air uniformly throughout the conditioned space.

B. The type of unit, margin, material, finish, etc., shall be as shown on the drawing schedule. Flat-oval inlets are not acceptable for connection to flexible ducts.

C. All margins shall be compatible with ceiling types specified (including 'Thin-Line' T-bar lay-in grid system). Any discrepancies in contract documents should be brought to the attention of the Architect/Engineer, in writing, prior to Bid Date. Submission of Bid indicates ceiling and air inlet and outlet types have been coordinated.

D. The capacity and size of the unit shall be as shown on the drawings.

E. All units shall handle the indicated cfm as shown on the drawings while not exceeding an NC level of 25, referenced to 10^{-12} watts with a 10 dB room effect. Noise in classrooms may not exceed 35 dBA or 55 dBC per ANSI Standard S12.60-2002 and ASHRAE 70.

F. Diffusers shall be architectural solid square panel and flush with ceiling.

G. The exposed surface shall be smooth, flat and free of visible fasteners. The face panel shall be 22 gauge steel with a rolled edge or shall be 18 gauge with a smooth ground, uniform edge.

H. The back pan shall be one piece 22 gauge stamped and shall include an integral inlet. (Welded inlets and corner joints are not acceptable).

I. Diffusers with a 24x24 back pan shall have a minimum 18x18 face panel size. Diffusers with a 12x12 back pan shall have a minimum 9x9 face panel size.

J. The face panel shall be mechanically fastened to the back panel with steel components. (Plastic fasteners are not acceptable.)

K. Manufacturers:

1. Tuttle & Bailey
2. Titus
3. Price
4. Nailor
5. Carnes
6. Metalaire
7. Krueger
8. Anemostat
9. Raymon Donco

2.3 AIR TERMINALS - SQUARE STEPDOWN CONE DIFFUSERS

A. Reference to a diffuser means an air supply device, ceiling mounted, that shall diffuse air uniformly throughout the conditioned space.

B. The type of unit, margin, material, finish, etc., shall be as shown on the drawing schedule. Flat-oval inlets are not acceptable for connection to flexible ducts.

C. All margins shall be compatible with ceiling types specified (including 'Thin-Line' T-bar lay-in grid system). Any discrepancies in contract documents should be brought to the attention of the Architect/Engineer, in writing, prior to Bid Date. Submission of Bid indicates ceiling and air inlet and outlet types have been coordinated.

D. The capacity and size of the unit shall be as shown on the drawings.

E. All units shall handle the indicated cfm as shown on the drawings while not exceeding an NC level of 25, referenced to 10^{-12} watts with a 10 dB room effect. Noise in classrooms may not exceed 35 dBA or 55 dBC per ANSI Standard S12.60-2002 and ASHRAE 70.

F. Diffusers shall be drop face construction.

G. Diffuser shall be entirely constructed of stamped panel and a minimum of two stepdown diffusion cones.

H. Stepdown cones shall be mechanically fastened to panel with metal fasteners. Diffuser stepdown cones glued, fastened with plastic clips, or otherwise attached to face panel will not be acceptable.

I. Each stepdown cone shall be one-piece stamped construction. The cones shall be removable for cleaning.

J. Diffusers shall be constructed of minimum 24 gauge steel.

K. Manufacturers:

1. Tuttle & Bailey
2. Titus
3. Price
4. Nailor
5. Carnes
6. Metalaire
7. Krueger
8. Anemostat
9. Raymon Donco

2.4 AIR TERMINALS - SQUARE MODULAR CORE DIFFUSERS

A. Reference to a diffuser means an air supply device, ceiling mounted, that shall diffuse air uniformly throughout the conditioned space.

B. The type of unit, margin, material, finish, etc., shall be as shown on the drawing schedule.

C. All margins shall be compatible with ceiling types specified (including 'Thin-Line' T-bar lay-in grid system). Any discrepancies in contract documents should be brought to the attention of the Architect/Engineer, in writing, prior to bid date. Submission of bid indicates ceiling and air inlet and outlet types have been coordinated.

D. The capacity and size of the unit shall be as shown on the drawings.

E. All units shall handle the indicated cfm as shown on the drawings while not exceeding an NC level of 25, referenced to 10^{-12} watts with a 10 dB room effect. Noise in classrooms may not exceed 35 dBA or 55 dBC per ANSI Standard S12.60-2002 and ASHRAE 70.

F. Modular core diffusers shall consist of an outer frame assembly to facilitate mounting and shall include an integral square collar to allow connection to the square duct. Where shown on the drawings, the diffuser shall be supplied with a square to round adapter. Flat-oval inlets are not acceptable for connection to flexible ducts.

G. The diffuser core shall consist of fixed louver directional modules that may be field adjusted from the diffuser face without any type of tools or mechanical device for one-way, two-way, two-way corner ,three-way or four-way horizontal discharge airflow.

H. Each louvered module shall be removable to allow access to any damper or other component in or near the diffuser neck.

I. The core's blade spacing shall be 1 inch on center.

J. Manufacturers:

1. Tuttle & Bailey
2. Titus
3. Price
4. Nailor
5. Carnes
6. Metalaire
7. Krueger
8. Anemostat
9. Raymon Donco

2.5 AIR TERMINALS - LAMINAR FLOW DIFFUSERS

A. Perforated panel diffuser to be laminar flow type, aluminum construction with manufacturer's standard white baked enamel or acrylic finish. Diffuser shall deliver air to the space with zero aspiration at the face of the perforated plate. Velocities in the plane of the perforated plate shall vary no more than 10%.

B. With a design temperature difference of 10°F, average velocity at four feet below the diffuser face shall not exceed 54 fpm. Static pressure at 20 cfm per square foot face velocity shall not exceed 0.05 water column. NC level shall not exceed 27.

C. Plate shall be retained to the module frame through the use of quarter-turn fasteners. Safety retainers of stainless steel cable or chain shall be provided to prevent accidental dropping of plate. Distribution plate shall be installed in aluminum mounting frame.

D. Fill-in panels identical in appearance to the active air distribution modules shall be furnished where shown on the plans.

E. Filters: MERV 17 HEPA 3" (75 mm) thick filter. Filter efficiency shall be based on ANSI/UL 586. Maximum pressure drop 0.25in.w.c. (0.06kpa) at 60FPM (0.3MPS). Filters shall not be installed until air balancing occurs. Provide two (2) sets of filters. Install one set immediately prior to balancing. Turn over second set to the Owner at completion.

F. Provide integral filter locating indicator light in frame face.

G. Provide integral aerosol injection port with dispersion tube and static pressure port for field test and certification.

H. Manufacturer:

1. Precision Air Products Co. PAT
2. Titus
3. Tuttle & Bailey
4. Krueger

5. Metalaire
6. Nailor

2.6 AIR TERMINALS - CRITICAL ENVIRONMENT - RADIAL FLOW DIFFUSERS - FLUSH FACE

A. Radial flow diffusers shall deliver a high volume of low velocity air in a radial air pattern for minimal entrainment of room air.

B. Provide performance data for air volume, initial pressure drop, sound levels, and throw. All data must be tested in accordance with the most recent publication of ASHRAE Standard 70.

C. Each diffuser shall supply a two-way or one-way radial air pattern as indicated on the drawings.

D. Construction:

1. Diffuser frame, border, and deflector blade material shall be aluminum.
2. Plenum, and equalization baffle material shall be aluminumstainless steel.
3. Perforated face shall be steel aluminum stainless steel.

E. The diffuser face shall be flush with the ceiling.

F. The diffuser face shall open easily and include safety retainer cables for cleaning from the room side without moving the plenum.

G. Where the drawings require diffusers to include filters, the diffuser shall be provided with an airtight filter housing. Filters shall be furnished with the diffuser of the type and size indicated. Filters shall not be installed until air balancing occurs, and one additional set shall be left with the Owner at completion.

H. Refer to drawings for quantities, sizes, capacities, finishes, and any additional information.

I. Manufacturer:

1. Price
2. Titus
3. Nailor
4. Carnes
5. Metalaire

2.7 AIR TERMINALS - LINEAR DIFFUSERS

A. Plenum Slot Diffusers (Lay-In):

1. The type of unit, margin size, material, finish, etc., shall be as shown on the Drawing Schedule. Flat-oval inlets are NOT acceptable for connection to flexible ducts. Provide sheet metal oval-to-round transition if required.
2. The capacity and size of the unit shall be as shown on the drawings.
3. All units shall handle the indicated cfm as shown on the drawings while not exceeding an NC level of 25, referenced to 10^{-12} watts with a 10 dB room effect. Noise in classrooms may not exceed 35 dBA or 55 dBC per ANSI Standard S12.60-2002 and ASHRAE 70.
4. Install T-bars on both sides of diffusers for lay-in ceiling system, install manufacturer frame for sheetrock or plaster ceiling system. Diffuser margins system shall be compatible with ceiling types specified, color to match ceiling system. Contractor shall coordinate margin types with ceilings prior to submitting shop drawings.
5. Linear diffusers and mounting frames shall be furnished as one piece up to 5' in length.
6. Diffusers shall be furnished with factory installed adjustable "ice tong" style pattern deflectors capable of providing 180° pattern adjustment.

7. A manual volume damper shall be furnished and installed by the Contractor in branch ductwork to each slot diffuser. Balancing dampers shall not be installed in supply plenum or at air outlet unless otherwise indicated on the drawings.
8. Number and width of slots shall be as shown on the drawings.
9. Provide integral insulated plenum for each linear diffuser. Refer to linear diffuser supply plenum specification section for details.
10. Manufacturers:

    a. Tuttle & Bailey ITPS
    b. Carnes DA
    c. Price TBD
    d. Krueger PTBS
    e. Nailor 5800
    f. Titus TBD
    g. Metalaire
    h. Anemostat API
    i. Raymon Donco SAT

11. Linear diffusers for fire-rated ceiling shall be UL labeled with a non-adjustable air pattern. Airflow direction shall be as shown on the drawings.
12. Manufacturers for fire-rated diffusers:

    a. Kees FRK-UL
    b. Titus TBD-FR
    c. Krueger PFTBS
    d. Price TBD2-FR
    e. Raymon Donco 2000FR
    f. Metalaire

B. Linear Slot Diffusers (Continuous):

1. The type of unit, margin size, material, finish, etc., shall be as shown on the Drawing Schedule. Flat-oval inlets are NOT acceptable for connection to flexible ducts. Provide sheet metal oval-to-round transition if required.
2. The capacity and size of the unit shall be as shown on the drawings.
3. All units shall handle the indicated cfm as shown on the drawings while not exceeding an NC level of 25, referenced to 10^{-12} watts with a 10 dB room effect. Noise in classrooms may not exceed 35 dBA or 55 dBC per ANSI Standard S12.60-2002 and ASHRAE 70.
4. Install T-bars on both sides of diffusers for lay-in ceiling system, install manufacturer frame for sheetrock or plaster ceiling system. Diffuser margins system shall be compatible with ceiling types specified, color to match ceiling system. Contractor shall coordinate margin types with ceilings prior to submitting shop drawings.
5. Provide with concealed fasteners for installation in the field.
6. Linear diffusers and mounting frames shall be furnished as one piece up to 6' in length. Provide auxiliary support per manufacturer's recommendations for slot diffusers greater than 4' in length.
7. Diffusers shall be furnished with adjustable pattern deflectors capable of providing 180° pattern adjustment.
8. A manual volume damper shall be furnished and installed by the Contractor in branch ductwork to each slot diffuser. Balancing dampers shall not be installed in supply plenum or at air outlet unless otherwise indicated on the drawings.
9. Number and width of slots shall be as shown on the drawings.
10. Provide insulated plenum for each linear diffuser. Refer to linear diffuser supply plenum specification section for details.
11. Manufacturers:

    a. Tuttle & Bailey 6000/7000
    b. Carnes CH
    c. Price SDS
    d. Krueger 1900
    e. Nailor 5000
    f. Titus ML

g. Anemostat SLAD
h. Raymon Donco HPL
i. Metalaire

C. Linear Slot Diffusers (High Performance):

1. The type of unit, margin size, material, finish, etc., shall be as shown on the Drawing Schedule. Flat-oval inlets are NOT acceptable for connection to flexible ducts. Provide sheet metal oval-to-round transition if required.
2. The capacity and size of the unit shall be as shown on the drawings.
3. All units shall handle the indicated cfm as shown on the drawings while not exceeding an NC level of 25, referenced to 10^{-12} watts with a 10 dB room effect per ANSI/ASHRAE 70.
4. Install T-bars on both sides of diffusers for lay-in ceiling system, install manufacturer frame for sheetrock or plaster ceiling system. Diffuser margins system shall be compatible with ceiling types specified, color to match ceiling system. Contractor shall coordinate margin types with ceilings prior to submitting shop drawings.
5. Provide with concealed fasteners for installation in the field.
6. Linear slot diffusers and mounting frames shall be furnished as one piece up to 6' in length. Provide auxiliary support per manufacturer's recommendations for slot diffusers greater than 4' in length.
7. Diffusers shall be furnished with adjustable pattern deflectors.
8. A manual volume damper shall be furnished and installed by the Contractor in branch ductwork to each slot diffuser. Balancing dampers shall <u>not</u> be installed in supply plenum or at air outlet unless otherwise indicated on the drawings.
9. Number and width of slots shall be as shown on the drawings.
10. Provide insulated plenum for each linear diffuser. Refer to linear diffuser supply plenum specification section for details.
11. Manufacturers:

    a. Price JS
    b. Titus FL
    c. Krueger DF
    d. Anemostat FF
    e. Raymon Donco WF2000
    f. Metalaire

D. Linear Bar Grille Diffusers:

1. The type of unit, margin size, material, finish, etc., shall be as shown on the Drawing Schedule. Flat-oval inlets are NOT acceptable for connection to flexible ducts. Provide sheet metal oval-to-round transition if required.
2. The capacity and size of the unit shall be as shown on the drawings.
3. All units shall handle the indicated cfm as shown on the drawings while not exceeding an NC level of 25, referenced to 10^{-12} watts with a 10 dB room effect per ANSI/ASHRAE 70.
4. Install T-bars on both sides of diffusers for lay-in ceiling system, install manufacturer frame for sheetrock or plaster ceiling system. Diffuser margins system shall be compatible with ceiling types specified, color to match ceiling system. Contractor shall coordinate margin types with ceilings prior to submitting shop drawings.
5. Provide with concealed fasteners for installation in the field.
6. Linear bar diffusers and mounting frames shall be furnished as one piece up to 6' in length. Provide auxiliary support per manufacturer's recommendations for slot diffusers greater than 4' in length.
7. A manual volume damper shall be furnished and installed by the Contractor in branch ductwork to each bar grille. Balancing dampers shall <u>not</u> be installed in supply plenum or at air outlet unless otherwise indicated on the drawings.
8. Diffuser length and width, bar width, and spacing between bars shall be as shown on the drawings.
9. Provide insulated plenum for each linear diffuser. Refer to linear diffuser supply plenum section for details.
10. Manufacturers:

    a. Tuttle & Bailey 4000
    b. Carnes CC;CT;CW
    c. Krueger 1500/1600

d. Price LB
e. Nailor 4900
f. Titus CT
g. Metalaire 2000
h. Anemostat AL/TL
i. Raymon Donco DGB

2.8 AIR TERMINALS - LINEAR DIFFUSER SUPPLY PLENUM

A. Linear diffusers shall be provided with field fabricated or prefabricated supply plenums. Plenum shall be a minimum of 2-1/2" wider than total slot width, minimum length of slot, and minimum height of 10". Plenums with end fed duct connections shall not exceed 8' in length. The cross sectional area of the plenum shall be designed for a maximum velocity of 500 fpm and the aspect ratio shall be limited to a width-to-height ratio of less than 1.5. Plenums with side outlets shall be designed for a maximum velocity of 600 fpm and inlet ducts to plenum shall be spaced 5' on center maximum. Inlet ducts to plenums shall have a maximum velocity of 900 fpm. Flat-oval inlets are NOT acceptable for connection to flexible ducts. Provide sheet metal oval-to-round transition if required.

B. Plenum shall be constructed with 24 gauge galvanized steel and shall have side inlets unless shown otherwise on the drawings. Refer to Ductwork Application Schedule in Section 23 31 00 for insulation requirements.

C. End caps and required accessories shall be integral with the plenum or furnished and installed by the Mechanical Contractor.

D. A manual volume damper shall be furnished and installed by the Mechanical Contractor in branch ductwork to each slot diffuser. Balancing dampers shall not be installed in supply plenum or at air outlet unless otherwise indicated on the drawings

E. Prefabricated plenums shall be by the same manufacturer as the linear diffuser or Kees Inc.

2.9 AIR TERMINALS - DISPLACEMENT WALL DIFFUSERS

A. 18 gauge all metal construction, totally perforated front panel. Device shall be recessed in wall cavity provided by others.

B. Uniform velocity over entire face area, detachable front face. Total free area maximum of 13%. Provide with inner structure and baffles for low displacement ventilation applications.

C. Unit casing comprises fixed flow equalization for uniform velocity over entire discharge area.

D. Provide each with a supply collar. Refer to schedule on ventilation plans for connection locations for each device. Fabric, PVC, or other nonmetal based components shall not be used.

E. Electrostatic powder coated. Color selection by Architect/Engineer.

F. Units shall be submitted with verifiable test data indicating face velocity, throw, air volume, and sound level specified supply air temperature and volume.

G. Units shall be capable of 1:1 mixing ratio 18" from the diffuser face for use with standard air delivery.

H. Refer to Displacement Ventilation Schedule for size and type device for application.

I. The displacement units and damper device shall be by one manufacturer, with catalog data to support design parameters.

J. Manufacturer:

1. Titus
2. Halton
3. Krantz
4. Price

2.10 LOUVERS - BY GENERAL CONTRACTOR

A. Louvers shall be provided and installed by the General Contractor.

B. Coordinate exact sizes and locations required for ductwork connections.

2.11 BOXED CORNER LOUVERED PENTHOUSE - ALUMINUM

A. Louver:

1. Standard Louver Construction: Louvers shall be minimum 4" deep and constructed of extruded aluminum. Blade, jamb and sill thickness shall be minimum 0.081". Blades shall be spaced at a maximum of 5.1" apart. Louvers shall be of the drainable blade design with water collected on the leading edge of the blade and diverted to the jamb.

B. Louvers shall be of the drainable blade design with water collected on the leading edge of the blade and diverted to the jamb.

C. Louvers shall be furnished with aluminum bird screen mounted on the inside surface.

D. Size, cfm, finish and pressure drop for louvers shall be as scheduled on the drawings.

E. Louvers shall be sealed around perimeter to avoid moisture penetration between the louver frame and wall of penthouse.

F. Penthouse structure shall be constructed of an all-welded aluminum.

G. Curb cap shall be of 14 gauge formed aluminum with mitered corners continuously heliarc-welded. Penthouse roof shall be of the same material and cross-broken for added strength. Underside of roof shall be coated with insulating mastic.

H. All four corners of penthouse shall be boxed and insulated with drain.

I. Penthouse and throat shall be reinforced with extruded aluminum angle and have a minimum snow load of 40 lbs. per square foot.

J. Inlet area shall be minimum 150% of throat area for intake hoods. Outlet area shall be minimum 125% of throat area for exhaust hoods and relief vents.

K. Louvered penthouses shall be furnished with 12" high curb (above top of roof) and be of the size and type as shown on the drawings.

L. Manufacturers:

1. Arrow-United SPH
2. American Warming & Ventilating PE
3. Dowco P
4. Greenheck ESD
5. Louvers & Dampers Inc. EP
6. Ruskn PHB

7. Loren Cook PBH
8. Vent Products 7200 Series
9. United Enertech PFL

2.12 TIERED LOUVERED PENTHOUSE - ALUMINUM

A. Louvers shall be 4" deep and constructed of extruded aluminum with mitered corners. Blade, jamb and sill thickness shall be 0.081". Aluminum hood shall be 0.063" aluminum. Blades shall be spaced approximately 4" apart.

B. Louvers shall be of the drainable blade design with water collected on the leading edge of the blade and diverted to the jamb.

C. Louvers shall be furnished with aluminum bird screen mounted on the inside surface.

D. Size, cfm, finish and pressure drop for louvers shall be as scheduled on the drawings.

E. Penthouse structure shall be constructed of an all-welded aluminum.

F. Curb cap shall be of 14 gauge formed aluminum with mitered corners continuously heliarc-welded. Penthouse roof shall be of the same material and cross-broken for added strength. Underside of roof shall be coated with insulating mastic.

G. Corners of penthouse shall be mitered with internal reinforcement.

H. Penthouse and throat shall be reinforced with extruded aluminum angle and have a minimum snow load of 40 lbs. per square foot.

I. Inlet area shall be minimum 150% of throat area for intake hoods. Outlet area shall be minimum 125% of throat area for exhaust hoods and relief vents.

J. Louvered penthouses shall be furnished with 12" high curb (above top of roof) and be of the size and type as shown on the drawings.

K. Manufacturers:

1. ACME LVN
2. Dowco M
3. Greenheck WIH
4. Loren Cook TRE
5. Penn Barry PH
6. Ruskin PHM
7. Vent Products 7100 Series
8. Soler Palau RLX
9. United Enertech PEL

2.13 ROOF HOODS

A. Hoods shall be constructed of roll formed, interlocking aluminum panels. Vertical end panels are fully locked into hood.

B. Top of curb to hood inlet shall be minimum of 5”.

C. Curb cap shall be of 14 gauge formed aluminum with mitered corners continuously heliarc-welded. Hood shall be of the same material and cross-broken for added strength. Underside of hood shall be coated with insulating mastics.

D. Hoods shall be furnished with aluminum bird screen.

E. Hood and throat shall be reinforced with extruded aluminum angle and have a minimum snow load rating of 30 lbs. per square foot.

F. Size, cfm, finish and pressure drop for hoods shall be as scheduled on the drawings.

G. Inlet area shall be minimum 150% of throat area for intake hoods. Outlet area shall be minimum 125% of throat area for exhaust hoods and relief vents.

H. Hoods shall be furnished with 12" high curb (above top of roof) and be of the size and type as shown on the drawings.

I. Hood shall be furnished with motorized damper unless otherwise noted on the drawings.

J. Manufacturers:

1. Ammerman
2. Carnes
3. Cook
4. Greenheck
5. ILG
6. Jenco Fan
7. PennBarry
8. Twin City Fan & Blower
9. York
10. United Enertech GEV-GIV

2.14 ROOF CURBS

A. Furnish and install, where shown on the drawings, prefabricated roof curbs for all rooftop hood openings.

B. Roof Mounting Curb: Curb shall be sized to match curb cap of the hood. Minimum 18 inches, minimum 14 gauge galvanized steel, one-piece construction, insulated, all welded, wood nailer.

C. Curbs shall be unitized construction, 18 gauge galvanized steel, with continuous arc welded corner seams, insulated with 1-1/2" thick, 3 lb. density rigid fiberglass board and damper support angle.

D. Curb without cant - suitable for use with membrane type roof.

E. Manufacturers:

1. Same manufacturer as the equipment it serves or Pate, RPS, or Thy.

2.15 GOOSENECKS

A. Fabricate in accordance with SMACNA Duct Construction Standards of minimum 18 gauge galvanized steel.

B. Mount on minimum 12 inch high curb base.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General Installation Requirements:

1. Install items in accordance with manufacturers' instructions.
2. Install seismic restraints according to SMACNA's "Kitchen Equipment Fabrication Guidelines, Appendix 1, Guidelines for Seismic Restraints for Kitchen Equipment".
3. Check location of inlets and outlets and make necessary adjustments in position to conform to architectural features, symmetry, and lighting arrangement.
4. Install diffusers to ductwork with air tight connections.
5. Flexible ducts shall NOT be joined to flat-oval connections. Provide sheet metal oval-to-round transitions where required.
6. Supply air diffusers in operating rooms (Class B and C surgery) shall be opened and cleaned before the space is used.
7. Supply grille and register blades shall be aimed in the field to provide adequate air distribution in the space. All return grilles and registers blades shall be oriented to minimize sight distance beyond installed device.

B. Volume Damper:

1. Provide manual volume dampers on duct take-off to diffusers when there are multiple connections to a common duct. Locate volume dampers as far as possible from the air inlet or outlet.

C. Roof Hood and Louvered Penthouse:

1. If manufacturer has no recommendations, secure roof hoods and louvered penthouses to curbs with 1/4" lag bolts on 8" maximum centers.
2. Provide 20 gauge sheet metal duct blank-off behind louvers at unused portions of louver openings in exterior walls. Back with 2" rigid 3# density fiberglass board insulation with foil scrim facing the room. Seal watertight.

D. Maintaining Duct Cleanliness:

1. When grilles, registers, and diffusers are installed, Contractor shall prevent construction dust, dirt, and debris from entering ductwork as required by Section 23 05 00.

END OF SECTION 23 37 00

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SECTION 23 57 00 - HEAT EXCHANGERS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Shell and Tube Type Heat Exchangers.

B. Plate Type Heat Exchangers.

C. Accessories and Trim.

1.2 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 23 05 00. Indicate dimensions, locations, and size of tappings and performance data.

B. Submit manufacturer's installation instructions.

C. Submit design data in sufficient detail to verify that heat exchangers meet or exceed specified requirements.

D. Submit operation and maintenance data. Include start-up and shut down instructions, assembly drawings, and spare parts lists.

E. Submit certification that heat exchangers, accessories, and components will withstand seismic forces defined in Section 23 05 50. Include the following:

1. Basis for Certification: Indicate whether certification is based on actual test of assembled components or on calculation.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.3 EXTRA MATERIALS

A. Provide one set of wrenches for disassembly of plate type heat exchangers.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Protect internals from entry of foreign material by temporary caps on flanged openings.

1.5 REGULATORY REQUIREMENTS

A. Conform to Section 8D of the ANSI/ASME Boilers and Pressure Vessels Code for manufacture of tubular heat exchangers and heat exchanger shells.

PART 2 - PRODUCTS

2.1 SHELL AND TUBE TYPE HEAT EXCHANGER

A. Tubes: U-tube type with 3/4 inch OD minimum seamless copper tubes suitable for 125 psig working pressure.

B. Shell: Steel with threaded or flanged piping connections and necessary tappings, steel saddle and attaching U-bolts, prime coated.

C. Heads: Cast iron or fabricated steel with steel or bronze tube sheets, threaded or flanged for piping connections.

D. Water Chamber and Tube Bundle: Removable for inspection and cleaning.

E. Design: Heating fluid in shell and heated fluid in tubes.

F. Manufacturers:

1. Bell & Gossett - Sole Source

2.2 PLATE AND FRAME TYPE HEAT EXCHANGER

A. Furnish and install exchangers as scheduled on the drawings.

B. Units shall be complete, preassembled, pressure tested at the factory and flushed clean.

C. Units shall bear ASME code stamp for 125 psig water service.

D. Unit shall be rated and certified in accordance with AHRI 400.

E. Plate and frame heat exchangers shall be free standing with multiple plates, designed to allow for opening and cleaning in place. Steel baseplates for anchor bolts and lifting holes. Plates shall be 304 or 316 stainless steel with capability to withstand full operating pressure in one channel with zero pressure in the adjoining channel.

F. Gaskets shall be one-piece molded construction, of a material suitable for the fluids, pressures and temperature specified. Arrange gaskets so gasket failure cannot cause fluid mixing.

G. The plate pack shall be completely enclosed in a removable, rust protected shroud.

H. All exterior steel surfaces shall be shot blasted and coated with a two-part epoxy spray enamel baked at 250ºF.

I. Units shall be easily expanded by adding plates to accommodate future requirements. Frame shall have capacity for 50% additional plates.

J. Only one exchanger per frame is permitted. All pipe connections shall be to the fixed plate.

K. Manufacturers:

1. Bell & Gossett - Sole Source

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install to permit removal of tube bundle with minimum disturbance to installed equipment and piping.

C. Pitch shell to completely drain condensate.

D. Pipe relief valves and drain valves to nearest floor drain.

E. Support heat exchangers on welded steel pipe and angle floor stand.

3.2 STEAM-TO-WATER HEAT EXCHANGER TRIM

A. Shell: Pressure gauge tapping with pigtail siphon, vacuum breaker.

B. Water Inlet: Thermometer well, pressure gauge tapping, valved drain.

C. Water Outlet: Thermometer well for temperature regulator sensor, ASME rated safety relief valve, thermometer well and pressure gauge tappings.

END OF SECTION 23 57 00

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SECTION 23 73 13 - INDOOR MODULAR AIR HANDLING UNITS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Modular Indoor Handling Units.

1.2 QUALITY ASSURANCE

A. AHU Unit: Manufacturer specializing in design and manufacturing of the products specified in this section with a minimum of five years' experience.

B. Fabrication: Conform to AMCA 99 and AHRI 430.

C. Fan Performance Ratings: Conform to AMCA 210 and bear AMCA Certified Rating Seal.

D. Sound Ratings: Tested to AMCA 300.

E. Fan Energy Index (FEI): Fans shall meet or exceed the minimum FEI scheduled at the specified airflow, pressure, and air density (duty point). In no case shall the FEI at the specified duty point fall below 1.0.

F. Air Coils: Certify capacities, pressure drops, and selection procedures per AHRI 410.

G. Electrical control wiring shall be in accordance with NEC codes and ETL requirements.

H. Unit shall contain only UL listed components.

I. Conform to ASHRAE 90.1.

J. All air handling and distribution equipment mounted outdoors shall be designed to prevent rain intrusion into the airstream when tested at design airflow and with no airflow, using the rain test apparatus described in Section 58 of UL 1995.

1.3 SUBMITTALS

A. Submit shop drawings per Section 23 05 00. Indicate ratings, fan performance, motor electrical characteristics, gauges, material finishes, assembly, unit dimensions, weight loading, required clearances, construction details, and field connection details.

1. Product Data

a. Include data on all fans and accessories. Submit motor ratings and electrical characteristics, plus motor and electrical accessories. Submit multi-speed fan curves including minimum and maximum fan speed with specified operating points clearly plotted. Submit the Fan Energy Index (FEI) at the selected duty point.
b. Select fans using external static pressure noted in the schedule. Manufacturer responsible for calculation of internal static pressure. Manufacturer shall include an allowance for clean filters in the internal static pressure. An allowance for the difference between dirty filters and clean filters is included in the external static. Submit static pressure calculations showing total pressure drops, including tabulated internal pressure drops and specified external static pressure drops
c. Submit sound power level data for both fan outlet and casing radiation at rated capacity.

d. Submit shop drawings indicating coil and frame configurations, dimensions, materials, rows, connections, and rough-in dimensions
e. Submit manufacturer's data showing that coil capacities, pressure drops, and selection procedures meet or exceed specified requirements.
f. Provide a copy of data of filter media, filter performance data, filter assembly, and filter frames with unit submittal for reference only.

B. Submit manufacturer's installation instructions.

C. All base bid pricing shall be based on the drawings, schedules and this specification

1. If a manufacturer requests to deviate from the requirements described herein, the Manufacturer and/or Contractor may list voluntary add or deduct prices on the bid form. These voluntary prices will not be used in determining the low bidder.
2. All voluntary adds or deducts shall be discussed and agreed to by the Owner and Architect/Engineer prior to the award of the air handling unit bid and before the submittal process begins.

D. Any exceptions to the specifications must be clearly noted to the Architect/Engineer prior to acceptance. Contractor is responsible for all expenses due to exceptions.

E. Submit electrical power/controls wiring diagrams and product data indicating general assembly, components, safety controls, and service connections.

F. Submit operation and maintenance data. Include instructions for lubrication, filter replacement, motor and drive replacement, and spare parts lists.

G. Piezometer Flow Coefficients: Submittals for fans shall clearly indicate the size and associated flow coefficient for each fan included in the submittal as it relates to the piezometric airflow measuring system. Provide instructions indicating how the flow coefficient can be used in calculating fan airflow using the fan manufacturer provided empirically derived formulas for calculating airflow. Include recommended differential pressure controller ΔP range (inches w.g based on scheduled maximum airflows.

H. Submit certification that modular air handing units, accessories, and components will withstand seismic forces defined in Section 23 05 50. Include the following:

1. Basis for Certification: Indicate whether certification is based on actual test of assembled components or on calculation.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions. Dimensioned drawings shall provide a plan view and elevation views of the unit with various components (fans, coils, filter racks, air blender, dampers, doors etc.) labeled and their dimensions noted.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.4 EXTRA STOCK

A. Provide clean filters in all units at time of installation.

B. Provide clean filters in all units at project final completion after all interior finishes are complete.

C. Provide one additional set of replacement filters for all units. Deliver to Owner at job site.

D. One additional set of UV lamps.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site with protective coverings in-place. Loose shipped items must be in factory-provided protective coverings, with factory-installed shipping skids and lifting lugs.

B. Store unit in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures, and finish.

1.6 WARRANTY

A. Provide a manufacturer's 1-year parts and labor warranty against defects in material and workmanship.

1.7 GENERAL DESCRIPTION

A. Unit Location:

1. The air handling unit (AHU-1&2) is a variable air volume modular unit, located in a conditioned mechanical room in the penthouse.
2. The unit will be set on a concrete housekeeping pad by the Contractor.

B. Building Type: The building is a concrete structure utilizing cast-in-place concrete columns, beams, and a concrete slab floor system. (AHU-1&2)

C. Unit Description:

1. The unit shall contain all the components described in these specifications and shown on the drawings and schedules.
2. Refer to air handling unit drawings and schedules for additional information

PART 2 - PRODUCTS

2.1 MODULAR INDOOR AIR HANDLING UNITS

A. Manufacturers

1. Trane - Performance Climate Changer.
2. JCI/York - Solutions.

B. Housing:

1. Minimum 18 gauge G60 galvanized steel exterior panels reinforced and braced with galvanized steel framework.
2. Removable access panels for coil and fan removal.
3. Unit shall be double wall insulated constructed panel. Exterior wall shall be minimum 18 gauge galvanized steel. Interior wall shall be minimum 20 gauge solid galvanized steel. Cover all portions of the interior of the unit exposed to the airstream with steel to allow cleaning and prevent fiberglass erosion into the airstream. Foil facing on insulation shall not be acceptable as a substitute for double wall construction. The minimum R-value of the panel assemblies shall be 8.
4. Install a stainless steel drain pan under each cooling coil meeting requirements as outlined in ASHRAE 62.1. Extend drain pans the entire width of each coil, including piping and header if in the air stream, and from the upstream face of each coil to a distance 1/2 of the vertical coil height downstream from the downstream face. Pitch drain pans in two directions towards the outlet, with a slope of at least 1/8" per foot.

C. Units shall be draw-thru or blow-thru as noted on the drawings and shall not exceed the overall dimensions.

D. Doors:

1. Unit doors shall be double wall and insulated with the same materials used in the surrounding unit walls.
2. Doors shall contain a continuous neoprene bulb type gasket.
3. Each door shall contain a double pane tempered, reinforced or safety glass window.
4. Each door shall have a minimum of two (2) high compression type latches, operable from both sides.
5. Provide minimum 12" x 18" hinged access doors on both sides of the fan housing.
6. Unit shall have full height, galvanized, double wall, and hinged, removable access doors on both sides of fan.

E. Access Sections:

1. Provide access sections as shown on the drawings between unit sections. Provide access doors as shown on plans.

F. Air Blender:

1. Shall be of rotary mixing design employing radial blades
2. Shall be completely fixed devices with no moving parts.
3. Shall be provided with proper distances up and downstream such that the mixer is capable of providing a minimum mixing effectiveness of 75% and ±6°F standard deviation when mixing 50% outside air with 50% return air at 50°F inlet temperature differential.
4. Shall be sized for maximum velocities between 1,000 and 1,500 FPM.

G. Fan: Direct Drive Single Width, Single Inlet Plenum Multi-fan Array with Airfoil Blades:

a. Fan RPM shall not exceed 110% of scheduled value with the scheduled wheel type.
b. Statically and dynamically balanced.
c. Grease lubricated ball bearings selected for 200,000 hours L-50 life at the design operating conditions.
d. Provide extended lubrication lines for all bearings to an easily accessible location.
e. Factory balanced fans will be used with variable speed controls to operate at all speeds up to the design speed.
f. Fan(s) shall have internal spring isolators.
g. Multiple fan arrays shall be provided with gravity backdraft dampers on each fan inlet.
h. Piezometer Air Flow Measuring: Provide fan with factory installed piezometer ports for monitoring the pressure difference between the fan inlet and the smallest diameter of the inlet cone. Ports shall be installed by the factory to ensure proper location of the taps to match how the fans were tested. Orifices shall be factory drilled in the smallest diameter of the inlet cone venturi. Flow tubes from each venturi sensor shall extend to a termination plate mounted on the fan housing. High pressure flow probes shall be factory mounted in the low velocity fan inlet. Flow probes from the high-pressure sensor shall extend to a termination plate mounted on the fan housing. Provide piezometer on each fan in an array. Transducer for measuring differential pressure shall be provided by the Temperature Control Contractor (TCC). Include with fan submittal the empirically derived formulas developed by the fan manufacturer for each supply and return fan provided with the air handling unit, along with the recommended differential pressure transducer range.

H. Motors and Drives:

1. AC Induction Motors:

a. Motors shall have slide rails, adjusting screws, anchor bolts and bedplates.
b. Motor mounting bracket shall be adjustable to allow tightening of belts.
c. Motors shall be open drip-proof or TEFC type with grease lubricated bearings.

d. Motors shall be "variable frequency drive rated" when controlled by VFDs. Refer to Section 23 05 13.
e. Drives shall be V-belt type with adjustable pitch sheaves for units 20 HP and below. On units over 20 HP, use fixed sheaves. This Contractor shall provide replacement sheaves and belts as required to allow final air balancing.
f. No equipment shall be selected or operate above 90% of its motor nameplate rating.

2. Electronically Commutated Motors (ECM):

a. Motor shall be variable speed, constant torque, brushless DC motor for direct-drive applications. Electronics shall be encapsulated for moisture protection and shall integral surge protection. Motor shall be pre-wired for specific voltage and phase.

1) Motor frame shall be NEMA 48. UL recognized components shall be provided for the motor construction.

b. All EC motors shall be a minimum of 85% efficient at all speeds.
c. Motors shall be permanently lubricated, utilize ball bearings to match with the connected driven equipment.
d. Provide motor with on-board motor control module. Motor speed shall be limited to provide electronic overcurrent protection. Starter shall provide soft start to reduce inrush current and shall be controllable from 20% to 100% of full rated speed.

3. Variable Frequency Drives: Provided by temperature controls contractor and installed by electrical contractor.

I. Coils:

1. Hot Water Coils:

a. Extended surface type with seamless copper tubes and continuous plate type aluminum fins.
b. Suitable for continuous operation at 200 psi. Maximum air velocity of 1000 fpm.
c. Galvanized steel casing. Coil headers and U-bends shall not be exposed.
d. AHRI rated with 0.0005 tube side fouling factor.
e. Size coils sized based on EWT, EAT, gpm and cfm as scheduled. LAT shall be at least as high as scheduled. APD and WPD shall not exceed scheduled values.
f. Maximum 144 fins per foot.
g. Turbulators are not permitted unless tube velocities are below 2 FPS at design flow or noted otherwise. Turbulators shall be allowed if removable headers are specified.
h. Coils shall have drain and vent connections at supply and return headers with valves. Extend valving outside of the unit casing.
i. Install coils level to allow drainage.
j. Minimum 0.035" tube wall thickness.
k. Manufacturers:

1) Trane
2) York

2. Chilled Water Coils:

a. Extended surface type with seamless copper tubes and continuous plate type aluminum fins.
b. Stainless steel casing. Coil headers and U-bends shall not be exposed.
c. Maximum air velocity of 500 fpm.
d. AHRI rated with 0.0005 tube side fouling factor.
e. Coils shall be sized based on EWT, EAT, gpm and cfm as scheduled. The leaving DB, leaving WB, APD and WPD shall not exceed the scheduled values.
f. Maximum 144 fins per foot. No water carryover shall occur at design airflow and no anti-carryover coating shall be used.
g. Suitable for 200 psig operation.

h. Coils shall have drain and vent connections at supply and return headers. Install coils level for proper drainage. Coils shall be completely drainable. Minimum 1/2" OD tubes. Minimum 0.035" tube wall thickness.

J. Pre-Filter Section:

1. Provide side-loading particulate pre-filter section located downstream of return fan module as scheduled on drawings. Filter module shall be equipped with framing for 2" deep MERV-8 pleated media filters. Provide pre-filter module with full height hinged access door.
2. Maximum particulate pre-filter face velocity shall not exceed 230 feet/minute.
3. Reference Section 23 40 00 for filter requirements.

K. Final Filter Section:

1. Provide front-loading final filter section located downstream of supply fan module as scheduled on drawings. Filter module shall be equipped with framing for 12" deep cartridge filters with seals on all four sides where each filter is inserted in the frame to prevent air bypass. Provide final filter module with full height hinged access door. MERV-14
2. Maximum final filter face velocity shall not exceed 400 feet/minute.

L. Ultraviolet Germicidal Irradiation (UVGI):

1. Provided and installed by unit manufacturer. Refer to Section 23 33 00 for requirements.
2. Portal: The UV lamp plenum area shall be equipped with a viewing port for viewing the lamp assembly. Portal shall be constructed to allow viewing without the possibility of exceeding the Minimal Erythermal Dose.
3. Interlock: Include all interlocks and wiring to assure UV light assembly is not energized when any access door is opened. Provide lockout tagout switches to turn off UV lamps when persons are in the unit. Signage shall indicate CAUTION: ULTRAVIOLET ENERGY IN DUCT. DO NOT OVERRIDE THE SAFETY DEVICE OR OTHERWISE ACTIVATE LAMPS WITH DOOR OPEN.
4. Location: System shall be installed a minimum of 8 inches and maximum of 20 inches from coil surface (based on UVC manufacturer's calculations and recommendations.) Install on tracks allowing the UV fixture to slide into place. Tracks shall be designed so the UV fixtures can be easily maintained and replaced. Interlock all UV lamps to turn on and off together.
5. Provide a full set of ultraviolet lighting system replacement lamps as spare parts.

M. Electrical Power:

1. Provide factory-mounted, vapor-tight light fixtures in each accessible section of the unit. The fixture shall be complete with junction box, globe, aluminum globe guard, switch, and bulb. Lighting shall be wired to a single 120-volt point, terminating at a designated junction box mounted on the air-handling unit. The Mechanical Contractor is responsible to complete all wiring connection between shipping splits after assembly.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General Installation Requirements

1. Install per manufacturer's instructions.
2. During construction provide temporary closures of metal or taped polyethylene over openings into housing ducts to prevent dust from entering ductwork.
3. Seal all contractor installed penetrations airtight. Seal all openings prior to cleaning. Seal holes with proper SMACNA closures conforming to pressure class of the housing.
4. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

B. Coil Requirements:

1. Comb all coils to repair bent fins.
2. Extend coil drain and vent connections to outside unit housing. Provide normally closed valve on drain and vent connection outside of unit housing.

3.2 MANUFACTURER'S FIELD SERVICES

A. Provide factory authorized field representative for starting unit and training operator.

B. Prepare and start systems with installing contractor observation. Coordinate start up with Facilities Maintenance.

END OF SECTION 23 73 13

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SECTION 23 82 00 - TERMINAL HEAT TRANSFER UNITS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Finned Tube Radiation.

B. Convectors.

C. Unit Heaters.

D. Cabinet Heaters.

E. Fan Coil Units.

F. Chilled Beams.

1.2 QUALITY ASSURANCE

A. All filters shall be UL listed Class 1 or Class 2.

B. All electrical equipment shall have a UL label.

C. All gas fired units shall be AGA approved or UL listed.

D. All gas trains shall comply with utility company and code requirements.

E. All louvers and dampers shall have AMCA certified ratings.

F. Factory wired equipment shall conform to ANSI/NFPA 70.

1.3 SUBMITTALS

A. Submit shop drawings per Section 23 05 00.

B. Submit catalog data including arrangements, cross sections of cabinets, grilles, bracing, typical elevations.

C. Submit schedules of equipment and enclosures indicating length, number of pieces of element and enclosure, corner pieces, end caps, cap strips, access doors, and comparison of specified to actual heat output.

D. Indicate mechanical and electrical service locations and requirements. Show deviations from scheduled products.

E. Submit manufacturers' installation instructions.

F. Submit electrical power/controls wiring diagrams and product data indicating general assembly, components, safety controls, and service connections.

G. Submit certification that terminal heat transfer units, accessories, and components will withstand seismic forces defined in Section 23 05 50. Include the following:

1. Basis for Certification: Indicate whether certification is based on actual test of assembled components or on calculation.

    a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.4 DELIVERY, STORAGE AND HANDLING

A. Protect units from physical damage by storing in protected areas and leaving factory covers in place.

1.5 REGULATORY REQUIREMENTS

A. Conform to ASHRAE 90.1.

1.6 OPERATION AND MAINTENANCE DATA

A. Submit manufacturer's operation and maintenance data. Include operating, installation, maintenance and repair data, and parts listings.

PART 2 - PRODUCTS

2.1 CONVECTORS

A. Heating Elements: Seamless copper tubing mechanically expanded into evenly spaced aluminum fins, steel side plates and supports, factory air pressure tested at 100 psi under water.

B. Cabinet: 16 gauge steel front and top; 18 gauge steel back and ends; exposed corners rounded; easily secured removable front panels, adequately braced and reinforced for stiffness.

C. Finish: Factory applied baked enamel on exposed surfaces. Color selection by Architect.

D. At otherwise inaccessible valves, provide 6" x 7" minimum size factory-made hinged access doors integral with cabinet.

E. Manufacturers:

1. Sterling.
2. Vulcan.
3. Zehnder-Rittling.
4. Modine.
5. Shaw-Perkins.
6. Sigma.

2.2 UNIT HEATERS

A. Casings shall be heavy gauge steel with a baked finish.

B. Coils shall have copper heads and tubes, and aluminum fins.

C. Units shall have threaded pipe connections for hanger rods.

D. Fans shall be direct drive propeller type, factory balanced, with fan guards and totally enclosed motors with integral thermal overload protection.

E. Horizontal units shall have adjustable outlet air louvers.

F. Provide unit mounted and wired disconnects. Contractor shall be responsible for providing and wiring disconnect when using a manufacturer who does not provide factory mounted option.

G. Products:

1. Trane - S or P.
2. Daikin - UHH or UDH.
3. Modine - HS or V.
4. Vulcan - HV or VV.
5. Sterling HS or VS.
6. Zehnder-Rittling - H or V.
7. Sigma H or V.
8. Airtherm HA or VA.

2.3 HOT WATER AND STEAM CABINET HEATERS

A. Units shall include cabinet, fan, motor, coil, filter, inlet grille and discharge grille.

B. Cabinets: 16 gauge exposed surfaces and 18 gauge concealed surfaces. Plastic exposed parts are not acceptable.

C. Baked enamel finish. Color selected by Architect.

D. All motors shall be three-speed permanent split capacitor with integral thermal overload protection.

E. Coils shall have finned copper tubes.

F. Provide 1" thick disposable filters or 1/2" thick washable 65% aluminum filters ahead of all coils.

G. Provide a concealed unit mounted fan switch with "Off-High-Medium-Low" positions that doubles as disconnect.

H. Manufacturers:

1. Trane - 'Force-Flo.'
2. Sterling, Modine.
3. Zehnder-Rittling.
4. Sigma.
5. Vulcan.
6. Airtherm.
7. Beacon Morris.
8. Daikin.

2.4 FAN COIL UNITS

A. Units shall include cabinet, fan, motor, coils, filter and discharge grille.

B. Exposed cabinets shall be minimum 18 gauge steel with baked enamel finish, color selected by the Architect and no plastic exposed parts.

C. Fans: Centrifugal forward-curved, double-width with galvanized steel scrolls.

D. All motors shall be electronically commutated motor (ECM) with integral thermal overload protection.

E. Coils shall have copper headers and tubes and aluminum fins.

F. Install a drain pan under each cooling coil meeting requirements as outlined in ASHRAE 62.1. The drain pans shall extend the entire width of each coil, including piping and header if in the air stream. The length shall be as necessary to limit water droplet carryover beyond the drain pan to 0.0044oz per ft2 of face area per hour under peak sensible and peak dew point design conditions, considering both latent load and coil face velocity. Pitch drain pans in two directions towards the outlet, with a slope of at least 1/8" per foot.

G. Provide auxiliary drain pan to collect condensation in the valve compartment.

H. Provide condensate level switch to prevent unit from operating if the drain becomes blocked.

I. Provide condensate piping and tie into drainage system.

J. Filters: 1" woven glass fiber disposable type.

K. Provide a concealed unit-mounted fan switch with "Off-High- Medium-Low" positions that doubles as a disconnect. Provide a concealed unit-mounted fan switch with "Off-High- Medium-Low" positions that doubles as a disconnect. Provide a factory-installed manual switch disconnect with load side fuse to protect any fan coil units with a maximum overcurrent protection rating of 20 amps or less.

L. Provide oversized left and right end piping compartments.

M. Provide with tamperproof cabinet front.

N. Provide with a motor cord quick disconnect.

O. Units shall have a single coil for heating and cooling.

P. Units shall have separate heating and cooling coils.

Q. Manufacturers:

1. Air-Therm.
2. Trane
3. Daikin.
4. IEC.
5. Enviro-Tech/JCI.
6. Nailor.
7. Williams.
8. First Co.
9. Zehnder-Rittling.

2.5 CHILLED BEAMS

A. Active Chilled Beam:

1. Furnish and install active chilled beams of capacities as indicated on the drawings and within the mechanical equipment schedules. The primary airflow rate of the beams shall not exceed the value on the drawings. The beams shall be constructed and delivered to the job site as single units. Quantity and size shall be as shown on the drawings.
2. The face of the beam shall consist of a room air induction section of 50% free area perforated steel flanked by two linear supply slots. The entire visible face section shall be finished in white powder coat paint or as specified by the Architect. The face shall be removable and shall be hinged or safety wired and shall open to allow access to the coil.
3. Beams shall be provided with side and end details that will allow its integration into the applicable (nominal 24 inch wide) acoustical ceiling grid or gypsum ceiling as specified by the Architect. Beams used for exposed mounting applications shall include factory-mounted plates to ensure a horizontal discharge of the supply air.
4. The beams shall consist of a minimum 20 gauge galvanized steel housing encasing the integral sensible cooling coil and a plenum feeding a series of induction nozzles. The inside and outside surfaces of the housing and inlet spigot shall be finished with powder coat paint. A round duct connection shall be installed on the side for connecting the primary air supply to the chilled beam. The overall height of beams shall not exceed 12 inches.
5. Each beam shall be provided with a pressure tap that may be used to measure the pressure differential between the primary air plenum and the room. An airflow calibration label that relates this pressure differential reading with the primary and beam supply airflow rates shall also be affixed to the beam.
6. Beams shall be provided with connections for 2-pipe operation as indicated on plans and schedules. The coils shall be mounted horizontally and shall be manufactured with seamless copper tubing (1/2" outside diameter) with minimum 0.015-inch wall thickness mechanically fixed to aluminum fins. The aluminum fins shall be limited to no more than 10 fins per inch. The beam shall have a working pressure of at least 300 PSI and be factory tested for leakage at a minimum pressure of 360 PSI. Each chilled beam shall be provided with factory integrated drain and vent fittings. Unless otherwise specified, coil connections shall be bare copper for field sweating to the water supply circuit. Connections shall face upwards and be located near the end of the beam.
7. Beams shall be delivered clean, flushed, and capped to prevent ingress of dirt.
8. All performance shall be in compliance with that shown on the equipment schedule. Acoustical testing shall have been performed in accordance with ANSI S12.51.
9. Coils shall be rated in accordance with ARI Standard 410, but their cooling capacities shall be established in accordance to ASHRAE Standard 200-2015 for the specific application on the inlet side of the submitted chilled beam. Evidence of this testing must be included in the submittal.
10. Chilled water flow rates to the beams shall be limited to that which results in a maximum head loss of ten feet. Water flow velocities through the beam shall not exceed 4 FPS.
11. Manufacturers:

    a. Titus.
    b. Dadanco.
    c. Swegon.

B. Passive Chilled Beam:

1. Furnish and install passive chilled beams of capacities as indicated on the drawings and within the mechanical equipment schedules. The beams shall be constructed and delivered to the job site as single units. Quantity and size shall be as shown on the drawings.
2. The face of the beam shall consist of a coil section of minimum of 50% free area perforated steel. The entire visible face section shall be finished in white powder coat paint or as specified by the Architect. The face shall be removable and shall be hinged or safety wired and can be opened to allow access to the coil.
3. Beams shall be provided with side and end details that will allow its integration into the applicable (nominal 24-inch wide) acoustical ceiling grid or gypsum ceiling as specified by the Architect.
4. The beams shall consist of a minimum 20 gauge galvanized steel housing encasing the integral sensible cooling coil. The inside and outside surfaces of the housing shall be finished with powder coat paint. The overall height of beams shall not exceed 12 inches.

5. Beams shall be provided with connections for 2-pipe operation as indicated on plans and schedules. The coils shall be mounted horizontally and shall be manufactured with seamless copper tubing (1/2" outside diameter) with minimum 0.015-inch wall thickness mechanically fixed to aluminum fins. The aluminum fins shall be limited to no more than 6 fins per inch. The beam shall have a working pressure of at least 300 PSI and be factory tested for leakage at a minimum pressure of 360 PSI. Each chilled beam shall be provided with factory integrated drain and vent fittings. Unless otherwise specified, coil connections shall be bare copper for field sweating to the water supply circuit. Connections shall face upwards and be located near the end of the beam.
6. Beams shall be delivered clean, flushed, and capped to prevent ingress of dirt.
7. All performance shall be in compliance with that shown on the equipment schedule. Acoustical testing shall have been performed in accordance with ANSI S12.51.
8. Coils shall be rated in accordance with ARI Standard 410, but their cooling capacities shall be established in accordance to ASHRAE 200-2015 for the specific application on the inlet side of the submitted chilled beam. Evidence of this testing must be included in the submittal.
9. Chilled water flow rates to the beams shall be limited to that which results in a maximum head loss of 10 ft. Water flow velocities through the beam shall not exceed 4 FPS.
10. Manufacturers:

    a. Titus
    b. Dadanco
    c. Swegon

PART 3 - EXECUTION

3.1 INSTALLATION

A. General Installation Requirements:

1. Install all products per manufacturers' instructions.
2. Coordinate recess sizes for recessed equipment.
3. Protect units with protective covers during construction.
4. Comb all coils to repair bent fins.

B. Fin Tube:

1. Locate finned tube radiation as shown and run cover wall-to-wall, unless otherwise shown. Center elements under windows.

C. Unit Heater:

1. Hang unit heaters from building structure, not from piping. Mount as high as possible within manufacturer's recommended mounting height requirements. If unit heaters cannot be installed within manufacturer's recommended range, notify Architect/Engineer prior to mounting.

3.2 CLEANING

A. After construction is complete, including painting, clean exposed surfaces of units. Vacuum clean coils and inside of cabinets.

B. Touch-up marred or scratched surfaces of factory-finished cabinets, with materials furnished by manufacturer.

C. Install new filters.

END OF SECTION 23 82 00

SECTION 23 82 16 - AIR COILS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Water Coils.

1.2 SUBMITTALS

A. Submit shop drawings under provisions of Section 23 05 00.

B. Submit shop drawings indicating coil and frame configurations, dimensions, materials, rows, connections, and rough-in dimensions.

C. Submit manufacturer's installation instructions.

D. Submit manufacturer's data showing that coil capacities, pressure drops, and selection procedures meet or exceed specified requirements.

E. Submit electrical power/controls wiring diagrams and product data indicating general assembly, components, safety controls, and service connections.

F. Submit certification that air coils, accessories, and components will withstand seismic forces defined in Section 23 05 50. Include the following:

1. Basis for Certification: Indicate whether certification is based on actual test of assembled components or on calculation.

   a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.3 DELIVERY, STORAGE, AND HANDLING

A. Protect coil fins from crushing and bending by leaving in shipping cases until installation, and by storing indoors.

B. Protect coils from entry of dirt and debris with pipe caps or plugs.

C. Protect coolers from dirt and debris.

PART 2 - PRODUCTS

2.1 HOT WATER COILS

A. Extended surface type with seamless copper tubes and continuous plate type aluminum fins.

B. Suitable for continuous operation at 200 psi. Maximum air velocity of 1,000 fpm.

C. Galvanized steel casing.

D. AHRI rated with 0.0005 tube side fouling factor.

E. Coils shall be sized based on EWT, EAT, gpm and cfm as scheduled. LAT shall be at least as high as scheduled. APD and WPD shall not exceed scheduled values. APD shall not exceed .5" W.C. and WPD shall not exceed 10 feet of head.

F. Maximum 144 fins per foot.

G. Turbulators are not permitted. Turbulators shall not be allowed if removable headers are specified.

H. Coils shall have vent connections, with valves, at the supply and return headers.

I. Install coils level to allow drainage.

J. Coils scheduled for over 2,000 cfm shall have valved drain connections at both headers.

K. Headers and pipe connectors shall be copper or brass for use in copper piping systems or cast iron with ferrous pipe connectors for use in steel piping systems. If header material does not match the piping material, use dielectric fittings at the change in material.

L. All duct coils shall have slip and drive connections with clearance sufficient for removal of coils from ducts.

M. Minimum 0.024" tube wall thickness.

N. Manufacturers:

1. Trane
2. York
3. Daikin
4. Heatcraft
5. Commercial Coil
6. American Air Filter
7. Coilmaster

PART 3 - EXECUTION

3.1 INSTALLATION

A. General Installation Requirements:

1. Install coils in accordance with manufacturer's instructions. Pipe coils with air flow and water flow in opposite directions (counter flow).
2. Protect coils to prevent damage to fins and flanges.
3. Protect cooler to prevent damage.
4. Make connections to coils with offsets and unions or flanges to allow coil to be removed without disturbing valves.
5. Comb all coils to repair bent fins.

B. Duct Mounted Coil:

1. Install in ducts and casings in accordance with SMACNA HVAC Duct Construction Standards, Metal and Flexible.
2. Insulate U-bends located outside ducts or casings as specified for ductwork.

END OF SECTION 23 82 16

SECTION 26 05 00 - BASIC ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Requirements applicable to all Division 26 Sections. Also refer to Division 1 - General Requirements. This section is also applicable to Interior Communications Pathways Section 27 05 28. This section is also applicable to Fire Alarm and Detection Systems Section 28 31 00.

B. All materials and installation methods shall conform to the applicable standards, guidelines and codes referenced herein and within each specification section.

1.2 REFERENCES

A. NFPA 70 - National Electrical Code (NEC)

1.3 SCOPE OF WORK

A. This Specification and the associated drawings govern furnishing, installing, testing and placing into satisfactory operation the Electrical Systems.

B. The Contractor shall furnish and install all new materials as indicated on the drawings, and/or in these specifications, and all items required to make the portion of the Electrical Work a finished and working system.

C. Separate contracts will be awarded for the following work. The division of work listed below is for the contractors' convenience and lists a normal breakdown of the work. Please refer to the Construction Manager's scope statements for complete scope of work description.

D. Description of Systems shall be as follows:

1. Electrical power system to and including luminaires, equipment, motors, devices, etc.
2. Grounding system.
3. Fire alarm system.
4. Public address and intercom system.
5. Wiring of equipment furnished by others.
6. Removal work and/or relocation and reuse of existing systems and equipment.
7. Telecommunications rough-in, as shown on drawings, for installation of telecommunications equipment by others under separate contract.
8. Technology Systems as described in Division 27/28 and on the T-series documents as described in the Suggested Matrix of Scope Responsibility.
9. Furnish and install firestopping systems for penetrations of fire-rated construction associated with this Contractor's work.

E. Work Not Included:

1. Telecommunications cabling will be by Division 27, in raceways and conduits furnished and installed as part of the Electrical work.
2. Temperature control wiring for plumbing and HVAC equipment (unless otherwise indicated) will be by other Contractors.

1.4 OWNER FURNISHED PRODUCTS

A. The Owner will supply manufacturer's installation data for Owner-purchased equipment for this project.

B. This Contractor shall make all electrical system connections shown on the drawings or required for fully functional units.

C. This Contractor is responsible for all damage to Owner furnished equipment caused during installation.

1.5 WORK SEQUENCE

A. All work that will produce excessive noise or interference with normal building operations, as determined by the Owner, shall be scheduled with the Owner. It may be necessary to schedule such work during unoccupied hours. The Owner reserves the right to determine when restricted construction hours are required.

1.6 DIVISION OF WORK BETWEEN MECHANICAL, ELECTRICAL, and CONTROL CONTRACTORS

A. Division of work is the responsibility of the Prime Contractor. Any scope of work described at any location on the contract document shall be sufficient for including said requirement in the project. The Prime Contractor shall be solely responsible for determining the appropriate subcontractor for the described scope. In no case shall the project be assessed an additional cost for scope that is described on the contract documents on bid day. The following division of responsibility is a guideline based on typical industry practice.

B. Definitions:

1. "Mechanical Contractors" refers to the Contractors listed in Division 21/22/23 of this Specification.
2. "Technology Contractors" refers to the Contractors furnishing and installing systems listed in Division 27/28 of this Specification.
3. Motor Power Wiring: The single phase or 3 phase wiring extending from the power source (transformer, panelboard, feeder circuits, etc.) through disconnect switches and motor controllers to, and including the connections to the terminals of the motor.
4. Motor Control Wiring: The wiring associated with the remote operation of the magnetic coils of magnetic motor starters or relays, or the wiring that permits direct cycling of motors by means of devices in series with the motor power wiring. In the latter case, the devices are usually single phase, have "Manual-Off-Auto" provisions, and are usually connected into the motor power wiring through a manual motor starter.
5. Control devices such as start-stop push buttons, thermostats, pressure switches, flow switches, relays, etc., generally represent the types of equipment associated with motor control wiring.
6. Motor control wiring is single phase and usually 120 volts. In some instances, the voltage will be the same as the motor power wiring. When the motor power wiring exceeds 120 volts, a control transformer is usually used to give a control voltage of 120 volts.
7. Temperature Control Wiring: The wiring associated with the operation of a motorized damper, solenoid valve or motorized valve, etc., either modulating or two-position, as opposed to wiring that directly powers or controls a motor used to drive equipment such as fans, pumps, etc. This wiring will be from a 120-volt source and may continue as 120 volt, or be reduced in voltage (24 volt), in which case a control transformer shall be furnished as part of the temperature control wiring.
8. Control Motor: An electric device used to operate dampers, valves, etc. It may be two-position or modulating. Conventional characteristics of such a motor are 24 volts, 60 cycles, 1 phase, although other voltages may be encountered.
9. Low Voltage Technology Wiring: The wiring associated with the technology systems, used for analog or digital signals between equipment.
10. Telecommunications/Technology Rough-in: Relates specifically to the backboxes, necessary plaster rings and other miscellaneous hardware required for the installation or mounting of telecommunications/technology information outlets.

C. General:

1. The purpose of these Specifications is to outline the Electrical and Mechanical Contractors' responsibilities related to electrical work required for items such as temperature controls, mechanical equipment, fans, chillers, compressors, etc. The exact wiring requirements for much of the equipment cannot be determined until the systems have been selected and submittals approved. Therefore, the electrical drawings show only known wiring related to such items. All wiring not shown on the electrical drawings, but required for mechanical systems, is the responsibility of the Mechanical Contractor.
2. Where the drawings require the Electrical Contractor to wire between equipment furnished by the Mechanical Contractor, such wiring shall terminate at terminals provided in the equipment. The Mechanical Contractor shall furnish complete wiring diagrams and supervision to the Electrical Contractor and designate the terminal numbers for correct wiring.
3. The Electrical Contractor shall establish electrical utility elevations prior to fabrication and installation. The Electrical Contractor shall coordinate utility elevations with other trades. When a conflict arises, priority shall be as follows:

   a. Luminaires.
   b. Gravity flow piping, including steam and condensate.
   c. Electrical bus duct.
   d. Sheet metal.
   e. Cable trays, including access space.
   f. Other piping.
   g. Conduits and wireway.

D. Mechanical Contractor's Responsibility:

1. Assumes responsibility for internal wiring of all equipment furnished by the Mechanical Contractor.
2. Assumes all responsibility for miscellaneous items furnished by the Mechanical Contractor that require wiring but are not shown on the electrical drawings or specified in the Electrical Specification. If items such as relays, flow switches, or interlocks are required to make the mechanical system function correctly or are required by the manufacturer, they are the responsibility of the Mechanical Contractor.
3. Assumes all responsibility for Temperature Control wiring, if the Temperature Control Contractor is a Subcontractor to the Mechanical Contractor.
4. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

E. Temperature Control Contractor's or Subcontractor's Responsibility:

1. Wiring of all devices needed to make the Temperature Control System functional.
2. Verifying any control wiring on the electrical drawings as being by the Electrical Contractor. All wiring required for the Control System, but not shown on the electrical drawings, is the responsibility of the Temperature Control Contractor or Subcontractor.
3. Coordinating equipment locations (such as PE's, EP's, relays, transformers, etc.) with the Electrical Contractor, where wiring of the equipment is by the Electrical Contractor.
4. Temperature Controls Contractor shall provide all utilty submeters. Appropriate contractor shall provide installation (PC, MC, EC). Temperature Controls Contractor shall make connections to building management system.
5. Temperature Controls Contractor shall coordinate with Electrical Contractor to monitor status of and faults associated with the emergency generator. The building management system shall be used to exercise the generator.
6. Temperature Controls Contractor shall provide all variable frequency drives not furnished as an integral part of equipment. Power connections shall be by the Electrical Contractor. Control of VFD shall be by the Temperature Controls Contractor.
7. Temperature Controls Contractor shall provide a dedicated pathway (J-hooks, cable tray, etc.) and/or conduit system for building management system wiring.

F. Electrical Contractor's Responsibility:

1. Furnishes and installs all combination starters, manual starters and disconnect devices shown on the Electrical Drawings or indicated to be by the Electrical Contractor in the Mechanical Drawings or Specifications.
2. Installs and wires all remote-control devices furnished by the Mechanical Contractor or Temperature Control Contractor when so noted on the Electrical Drawings.
3. Furnishes and installs motor control and temperature control wiring, when noted on the drawings.
4. Furnishes, installs, and connects all relays, etc., for automatic shutdown of certain mechanical equipment (supply fans, exhaust fans, etc.) upon actuation of the Fire Alarm System.
5. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

G. General (Electrical/Technology):

1. "Electrical Contractor" as referred to herein shall be responsible for scope listed in Division 27/28 of this specification when the "Suggested Matrix of Scope Responsibility" indicated work shall be furnished and installed by the EC. Refer to the Contract Documents for this "Suggested Matrix of Scope Responsibility".
2. The purpose of these Specifications is to outline the Electrical and Technology Contractor's work responsibilities as related to Telecommunications Rough-in, conduit, cable tray, power wiring and Low Voltage Technology Wiring.
3. The exact wiring requirements for much of the equipment cannot be determined until the systems have been purchased and submittals approved. Therefore, only known wiring, conduits, raceways and electrical power related to such items is shown on the Technology drawings. Other wiring, conduits, raceways, junction boxes and electrical power not shown on the Technology Drawings but required for operation of the systems is the responsibility of the Technology Contractor and included in said Contractor's bid.
4. Where the Electrical Contractor is required to install conduit, conduit sleeves and/or power connections in support of Technology systems, the final installation shall not be until a coordination meeting between the Electrical Contractor and the Technology Contractor has convened to determine the exact location and requirements of the installation.
5. Where the Electrical Contractor is required to install cable tray that will contain Low Voltage Technology Wiring, installation shall not begin prior to a coordination review of the cable tray shop drawings by the Technology Contractor.

H. Technology Contractor's Responsibility:

1. Assumes all responsibility for the low voltage technology wiring of all systems, including cable support where open cable is specified.
2. Assumes all responsibility for all required backboxes, conduit and power connections not specifically shown as being furnished and installed by the Electrical Contractor on the "Suggested Matrix of Scope Responsibility".
3. Assumes all responsibility for providing and installing all ladder rack and other cable management hardware (as defined herein).
4. Responsible for providing the Electrical Contractor with the required grounding lugs or other hardware for each piece of technology equipment which is required to be bonded to the telecommunications ground bar.
5. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

1.7 COORDINATION DRAWINGS

A. Definitions:

1. Coordination Drawings: A compilation of the pertinent layout and system drawings that show the sizes and locations, including elevations, of system components and required access areas to ensure that no two objects will occupy the same space.

a. Mechanical trades shall include, but are not limited to, mechanical equipment, ductwork, fire protection systems, plumbing piping, medical gas systems, hydronic piping, steam and steam condensate piping, and any item that may impact coordination with other disciplines.
b. Electrical trades shall include, but are not limited to, electrical equipment, conduit 1.5" and larger, conduit racks, cable trays, pull boxes, transformers, raceway, busway, lighting, ceiling-mounted devices, and any item that may impact coordination with other disciplines.
c. Technology trades shall include, but are not limited to, technology equipment, racks, conduit 1.5" and larger, conduit racks, cable trays, ladder rack, pull boxes, raceway, ceiling-mounted devices, and any item that may impact coordination with other disciplines.
d. Maintenance clearances and code-required dedicated space shall be included.
e. The coordination drawings shall include all underground, underfloor, in-floor, in chase, and vertical trade items.

2. Spaces with open/cloud ceiling architecture shall indicate the overhead utilities and locate equipment as required to maintain clearance above lights. The intent for the installation is to maintain a maximum allowable vertical clearance and an organized/clean manner in the horizontal. Notify Architect/Engineer of the maximum clearance which can be maintained. Failure to comply will result in modifications with no cost to Owner.

a. In cloud ceiling architecture, when open cabling/wire and/or cable tray crosses gaps between ceiling clouds and/or walls, cabling is to transition to conduits to span the gaps in order to conceal cabling from below.

3. The contractors shall use the coordination process to identify the proper sequence of installation of all utilities above ceilings and in other congested areas, to ensure an orderly and coordinated end result, and to provide adequate access for service and maintenance.

B. Participation:

1. The contractors and subcontractors responsible for work defined above shall participate in the coordination drawing process.
2. One contractor shall be designated as the Coordinating Contractor for purposes of preparing a complete set of composite electronic CAD coordination drawings that include all applicable trades, and for coordinating the activities related to this process. The Coordinating Contractor for this project shall be the Mechanical Contractor.

a. The Coordinating Contractor shall utilize personnel familiar with requirements of this project and skilled as draftspersons/CAD operators, competent to prepare the required coordination drawings.

3. Electronic CAD drawings shall be submitted to the Coordinating Contractor for addition of work by other trades. IMEG will provide electronic file copies of ventilation drawings for contractor's use if the contractor signs and returns an "Electronic File Transfer" waiver provided by IMEG. IMEG will not consider blatant reproductions of original file copies an acceptable alternative for coordination drawings.

C. Drawing Requirements:

1. The file format and file naming convention shall be coordinated with and agreed to by all contractors participating in the coordination process and the Owner.

a. Scale of drawings:

1) General plans: 1/4 Inch = 1'-0" (minimum).
2) Mechanical, electrical, communication rooms, and including the surrounding areas within 10 feet: 1/2 Inch = 1'-0" (minimum).
3) Shafts and risers: 1/2 Inch = 1'-0" (minimum).
4) Sections of shafts and mechanical and electrical equipment rooms: 1/4 Inch = 1'-0" (minimum).
5) Sections of congested areas: 1/2 Inch = 1'-0" (minimum).

2. Ductwork layout drawings shall be the baseline system for other components. Ductwork layout drawings shall be modified to accommodate other components as the coordination process progresses.
3. There may be more drawings required for risers, top and bottom levels of mechanical rooms, and shafts.
4. The minimum quantity of drawings will be established at the first coordination meeting and sent to the A/E for review. Additional drawings may be required if other areas of congestion are discovered during the coordination process.

D. General:

1. Coordination drawing files shall be made available to the A/E and Owner's Representative. The A/E will only review identified conflicts and give an opinion, but will not perform as a coordinator.
2. A plotted set of coordination drawings shall be available at the project site.
3. Coordination drawings are not shop drawings and shall not be submitted as such.
4. The contract drawings are schematic in nature and do not show every fitting and appurtenance for each utility. Each contractor is expected to have included in the bid sufficient fittings, material, and labor to allow for adjustments in routing of utilities made necessary by the coordination process and to provide a complete and functional system.
5. The contractors will not be allowed additional costs or time extensions due to participation in the coordination process.
6. The contractors will not be allowed additional costs or time extensions for additional fittings, reroutings or changes of duct size, that are essentially equivalent sizes to those shown on the drawings and determined necessary through the coordination process.
7. The A/E reserves the right to determine space priority of equipment in the event of spatial conflicts or interference between equipment, piping, conduit, ducts, and equipment provided by the trades.
8. Changes to the contract documents that are necessary for systems installation and coordination shall be brought to the attention of the A/E.
9. Access panels shall preferably occur only in gypsum board walls or where indicated on the drawings. Avoid locating equipment, , junction boxes, and other items requiring access above hard ceilings. Minimize the need for access panels in hard ceilings.

    a. Access to mechanical, electrical, technology, and other items located above the ceiling shall be through accessible lay-in ceiling tile areas.
    b. Potential layout changes shall be made to avoid additional access panels.
    c. Additional access panels shall not be allowed without written approval from the A/E at the coordination drawing stage.
    d. Providing additional access panels shall be considered after other alternatives are reviewed and discarded by the A/E and the Owner's Representative.
    e. When additional access panels are required, they shall be provided without additional cost to the Owner.

10. Complete the coordination drawing process and obtain sign-off of the drawings by all contractors prior to installing any of the components.
11. Conflicts that result after the coordination drawings are signed off shall be the responsibility of the contractor or subcontractor who did not properly identify their work requirements, or installed their work without proper coordination.
12. Updated coordination drawings that reflect as-built conditions may be used as record documents.

1.8 QUALITY ASSURANCE

A. Contractor's Responsibility Prior to Submitting Pricing/Bid Data:

1. The Contractor is responsible for constructing complete and operating systems. The Contractor acknowledges and understands that the Contract Documents are a two-dimensional representation of a three-dimensional object, subject to human interpretation. This representation may include imperfect data, interpreted codes, utility guides, three-dimensional conflicts, and required field coordination items. Such deficiencies can be corrected when identified prior to ordering material and starting installation. The Contractor agrees to carefully study and compare the individual Contract Documents and report at once in writing to the Architect/Engineer any deficiencies the Contractor may discover. The Contractor further agrees to require each subcontractor to likewise study the documents and report at once any deficiencies discovered.
2. The Contractor shall resolve all reported deficiencies with the Architect/Engineer prior to awarding any subcontracts, ordering material, or starting any work with the Contractor's own employees. Any work performed prior to receipt of instructions from the Architect/Engineer will be done at the Contractor's risk.

B. Qualifications:

1. Only products of reputable manufacturers as determined by the Architect/Engineer are acceptable.
2. All Contractors and subcontractors shall employ only workmen who are skilled in their trades. At all times, the number of apprentices at the job site shall be less than or equal to the number of journeymen at the job site.

C. Compliance with Codes, Laws, Ordinances:

1. Conform to all requirements of the City of Springfield, MO Codes, Laws, Ordinances and other regulations having jurisdiction.
2. Conform to all published standards of Missouri State University.
3. If there is a discrepancy between the codes and regulations and these specifications, the Architect/Engineer shall determine the method or equipment used.
4. If the Contractor notes, at the time of bidding, that any parts of the drawings or specifications do not comply with the codes or regulations, Contractor shall inform the Architect/Engineer in writing, requesting a clarification. If there is insufficient time for this procedure, Contractor shall submit with the proposal a separate price to make the system comply with the codes and regulations.
5. All changes to the system made after the letting of the contract to comply with codes or the requirements of the Inspector, shall be made by the Contractor without cost to the Owner.
6. If there is a discrepancy between manufacturer's recommendations and these specifications, the manufacturer's recommendations shall govern.
7. If there are no local codes having jurisdiction, the current issue of the National Electrical Code shall be followed.

D. Permits, Fees, Taxes, Inspections:

1. Procure all applicable permits and licenses.
2. Abide by all laws, regulations, ordinances, and other rules of the State or Political Subdivision where the work is done, or as required by any duly constituted public authority.
3. Pay all charges for permits or licenses.
4. Pay all fees and taxes imposed by State, Municipal, and other regulatory bodies.
5. Pay all charges arising out of required inspections by an authorized body.
6. Pay all charges arising out of required contract document reviews associated with the project and as initiated by the Owner or authorized agency/consultant.
7. Where applicable, all fixtures, equipment and materials shall be listed by Underwriter's Laboratories, Inc. or a nationally recognized testing organization.
8. Pay all telephone company charges related to the service or change in service.

E. Examination of Drawings:

1. The drawings for the electrical work are completely diagrammatic, intended to convey the scope of the work and to indicate the general arrangements and locations of equipment, outlets, etc., and the approximate sizes of equipment.

2. Contractor shall determine the exact locations of equipment and rough-ins, and the exact routing of raceways to best fit the layout of the job. Conduit entry points for electrical equipment including, but not limited to, panelboards, switchboards, switchgear and unit substations, shall be determined by the Contractor unless noted in the contract documents.
3. Scaling of the drawings will not be sufficient or accurate for determining these locations.
4. Where job conditions require reasonable changes in arrangements and locations, such changes shall be made by the Contractor at no additional cost to the Owner.
5. Because of the scale of the drawings, certain basic items, such as junction boxes, pull boxes, conduit fittings, etc., may not be shown, but where required by other sections of the specifications or required for proper installation of the work, such items shall be furnished and installed.
6. If an item is either shown on the drawings or called for in the specifications, it shall be included in this contract.
7. The Contractor shall determine quantities and quality of material and equipment required from the documents. Where discrepancies arise between drawings, schedules and/or specifications, the greater and better-quality number shall govern.
8. Where used in electrical documents the word "furnish" shall mean supply for use, the word "install" shall mean connect up complete and ready for operation, and the word "provide" shall mean to supply for use and connect up complete and ready for operation.
9. Any item listed as furnished shall also be installed unless otherwise noted.
10. Any item listed as installed shall also be furnished unless otherwise noted.

F. Electronic Media/Files:

1. Construction drawings for this project have been prepared utilizing Revit.
2. Contractors and Subcontractors may request electronic media files of the contract drawings and/or copies of the specifications. Specifications will be provided in PDF format.
3. Upon request for electronic media, the Contractor shall complete and return a signed "Electronic File Transmittal" form provided by IMEG.
4. If the information requested includes floor plans prepared by others, the Contractor will be responsible for obtaining approval from the appropriate Design Professional for use of that part of the document.
5. The electronic contract documents can be used for preparation of shop drawings and as-built drawings only. The information may not be used in whole or in part for any other project.
6. The drawings prepared by IMEG for bidding purposes may not be used directly for ductwork layout drawings or coordination drawings.
7. The use of these CAD documents by the Contractor does not relieve them from their responsibility for coordination of work with other trades and verification of space available for the installation.
8. The information is provided to expedite the project and assist the Contractor with no guarantee by IMEG as to the accuracy or correctness of the information provided. IMEG accepts no responsibility or liability for the Contractor's use of these documents.

G. Field Measurements:

1. Verify all pertinent dimensions at the job site before ordering any conduit, conductors, wireways, bus duct, fittings, etc.

1.9 SUBMITTALS

A. Submittals shall be required for the following items, and for additional items where required elsewhere in the specifications or on the drawings.

1. Submittals list:

Referenced Specification Section	Submittal Item	Coordination Drawing
26 05 35	Surface Raceways	
26 12 19	Pad-Mounted, Liquid-Filled Transformers	Yes

Referenced Specification Section	Submittal Item	Coordination Drawing
26 22 00	Dry Type Transformers	Yes
26 23 00	Low-Voltage Switchgear	Yes
26 24 13	Switchboards	Yes
26 24 16	Panelboards	Yes
26 27 26	Wiring Devices	Ceiling mount
26 28 16	Disconnect Switches	Yes
26 29 23	Variable Frequency Drives	Yes
26 32 13	Packaged Engine Generator Systems	Yes
26 36 00	Transfer Switch	Yes
26 43 00	Surge Protection Devices	
26 51 19	LED Lighting	Yes
28 31 00	Fire Alarm and Detection Systems	Yes

General Submittal Procedures: In addition to the provisions of Division 1, the following are required:

2. Transmittal: Each transmittal shall include the following:

   a. Date
   b. Project title and number shall match MSU project title and project number.
   c. Contractor's name and address
   d. Division of work (e.g., electrical, plumbing, heating, ventilating, etc.)
   e. Description of items submitted and relevant specification number
   f. Notations of deviations from the contract documents
   g. Other pertinent data

3. Submittal Cover Sheet: Each submittal shall include a cover sheet containing:

   a. Date
   b. Project title and number shall match MSU project title and project number.
   c. Architect/Engineer
   d. Contractor and subcontractors' names and addresses
   e. Supplier and manufacturer's names and addresses
   f. Division of work (e.g., electrical, plumbing, heating, ventilating, etc.)
   g. Description of item submitted (using project nomenclature) and relevant specification number
   h. Notations of deviations from the contract documents
   i. Other pertinent data
   j. Provide space for Contractor's review stamps

4. Composition:

   a. Submittals shall be submitted using specification sections and the project nomenclature for each item.
   b. Individual submittal packages shall be prepared for items in each specification section. All items within a single specification section shall be packaged together where possible. An individual submittal may contain items from multiple specifications sections if the items are intimately linked (e.g., pumps and motors).
   c. All sets shall contain an index of the items enclosed with a general topic description on the cover.

5. Content: Submittals shall include all fabrication, erection, layout, and setting drawings; manufacturers' standard drawings; schedules; descriptive literature, catalogs and brochures; performance and test data; wiring and control diagrams; dimensions; shipping and operating weights; shipping splits; service clearances; and all other drawings and descriptive data of materials of construction as may be required to show that the materials, equipment or systems and the location thereof conform to the requirements of the contract documents.

6. Contractor's Approval Stamp:

   a. The Contractor shall thoroughly review and approve all shop drawings before submitting them to the Architect/Engineer. The Contractor shall stamp, date and sign each submittal certifying it has been reviewed.
   b. Unstamped submittals will be rejected.
   c. The Contractor's review shall include, but not be limited to, verification of the following:

      1) Only approved manufacturers are used.
      2) Addenda items have been incorporated.
      3) Catalog numbers and options match those specified.
      4) Performance data matches that specified.
      5) Electrical characteristics and loads match those specified.
      6) Equipment connection locations, sizes, capacities, etc. have been coordinated with other affected trades.
      7) Dimensions and service clearances are suitable for the intended location.
      8) Equipment dimensions are coordinated with support steel, housekeeping pads, openings, etc.
      9) Constructability issues are resolved (e.g., weights and dimensions are suitable for getting the item into the building and into place, sinks fit into countertops, etc.).

   d. The Contractor shall review, stamp and approve all subcontractors' submittals as described above.
   e. The Contractor's approval stamp is required on all submittals. Approval will indicate the Contractor's review of all material and a complete understanding of exactly what is to be furnished. Contractor shall clearly mark all deviations from the contract documents on all submittals. If deviations are not marked by the Contractor, then the item shall be required to meet all drawing and specification requirements.

7. Submittal Identification and Markings:

   a. The Contractor shall clearly mark each item with the same nomenclature applied on the drawings or in the specifications.
   b. The Contractor shall clearly indicate the size, finish, material, etc.
   c. Where more than one model is shown on a manufacturer's sheet, the Contractor shall clearly indicate exactly which item and which data is intended.
   d. All marks and identifications on the submittals shall be unambiguous.

8. Schedule submittals to expedite the project. Coordinate submission of related items.
9. Identify variations from the contract documents and product or system limitations that may be detrimental to the successful performance of the completed work.
10. Reproduction of contract documents alone is not acceptable for submittals.
11. Incomplete submittals will be rejected without review. Partial submittals will only be reviewed with prior approval from the Architect/Engineer.
12. Submittals not required by the contract documents may be returned without review.
13. The Architect/Engineer's responsibility shall be to review one set of shop drawing submittals for each product. If the first submittal is incomplete or does not comply with the drawings and/or specifications, the Contractor shall be responsible to bear the cost for the Architect/Engineer to recheck and handle the additional shop drawing submittals.
14. Submittals shall be reviewed and approved by the Architect/Engineer before releasing any equipment for manufacture or shipment.
15. Contractor's responsibility for errors, omissions or deviation from the contract documents in submittals is not relieved by the Architect/Engineer's approval.
16. Schedule shall allow for adequate time to perform orderly and proper review of submittals, including time for consultants and Owner if required, and resubmittals by Contractor if necessary, and to cause no delay in Work or in activities of Owner or other contractors.

    a. Allow at least two weeks for Architect's/Engineer's review and processing of each submittal.

17. Architect/Engineer reserves the right to withhold action on a submittal which, in the Architect/Engineer's opinion, requires coordination with other submittals until related submittals are received. The Architect/Engineer will notify the Contractor, in writing, when they exercise this right.

B. Electronic Submittal Procedures:

1. Distribution: Email submittals as attachments to all parties designated by the Architect/Engineer, unless a web-based submittal program is used.
2. Transmittals: Each submittal shall include an individual electronic letter of transmittal.
3. Format: Electronic submittals shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Submittals that are not legible will be rejected. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.
4. File Names: Electronic submittal file names shall include the relevant specification section number followed by a description of the item submitted, as follows. Where possible, include the transmittal as the first page of the PDF instead of using multiple electronic files.

    a. Submittal file name: Lead file names with the abbreviated University project number (21-116). Example 21-116 26 XX XX.description.YYYYMMDD
    b. Transmittal file name: Lead file names with the abbreviated University project number (21-116). Example 21-116 26 XX XX.description.YYYYMMDD

5. File Size: Files shall be transmitted via a pre-approved method. Larger files may require an alternative transfer method, which shall also be pre-approved.

1.10 CHANGE ORDERS

A. A detailed material and labor takeoff shall be prepared for each change order, along with labor rates and markup percentages. Change orders shall be broken down by sheet or associated individual line item indicated in the change associated narrative, whichever provides the most detailed breakdown. Change orders with inadequate breakdown will be rejected.

B. Itemized pricing with unit cost shall be provided from all distributors and associated subcontractors.

C. Change order work shall not proceed until authorized.

1.11 PRODUCT DELIVERY, STORAGE, HANDLING and MAINTENANCE

A. Exercise care in transporting and handling to avoid damage to materials. Store materials on the site to prevent damage.

B. Keep all materials clean, dry and free from damaging environments.

C. Coordinate the installation of heavy and large equipment with the General Contractor and/or Owner. If the Electrical Contractor does not have prior documented experience in rigging and lifting similar equipment, he/she shall contract with a qualified lifting and rigging service that has similar documented experience. Follow all equipment lifting and support guidelines for handling and moving.

D. Contractor is responsible for moving equipment into the building and/or site. Contractor shall review site prior to bid for path locations and any required building modifications to allow movement of equipment. Contractor shall coordinate the work with other trades.

1.12 NETWORK / INTERNET CONNECTED EQUIPMENT

A. These specifications may require certain equipment or systems to have network, Internet and/or remote access capability ("Network Capability"). Any requirement for Network Capability shall be interpreted only as a functional capability and is not to be construed as authority to connect or enable any Network Capability. Network Capability may only be connected or enabled with the express written consent of the Owner.

1.13 WARRANTY

A. Provide one-year warranty for all fixtures, equipment, materials, and workmanship.

B. The warranty period for all work in this specification Division shall commence on the date of Substantial Completion or successful system performance whichever occurs later. The warranty may also commence if a whole or partial system or any separate piece of equipment or component is put into use for the benefit of any party other than the installing contractor with prior written authorization of the Owner. In this instance, the warranty period shall commence on the date when such whole system, partial system or separate piece of equipment or component is placed in operation and accepted in writing by the Owner.

C. Warranty requirements extend to correction, without cost to the Owner, of all work found to be defective or nonconforming to the contract documents. The Contractor shall bear the cost of correcting all damage due to defects or nonconformance with contract documents excluding repairs required as a result of improper maintenance or operation, or of normal wear as determined by the Architect/Engineer.

1.14 INSURANCE

A. This Contractor shall maintain insurance coverage as set forth in Division 1 of these specifications.

1.15 MATERIAL SUBSTITUTION

A. Coordinate substitution requirements with requirements outlined in Planning, Design & Construction Instructions to Bidders and General Conditions.

B. Where several manufacturers’ names are given, the manufacturer for which a catalog number is given is the basis for job design and establishes the quality.

C. Equivalent equipment manufactured by the other listed manufacturers may be used. Contractor shall ensure that all items submitted by these other manufacturers meet all requirements of the drawings and specifications and fits in the allocated space. When using other listed manufacturers, the Contractor shall assume responsibility for any and all modifications necessary (including, but not limited to structural supports, electrical connections and rough-in, and regulatory agency approval, etc.) and coordinate such with other contractors. The Architect/Engineer shall make the final determination of whether a product is equivalent.

D. Any material, article or equipment of other unnamed manufacturers which will adequately perform the services and duties imposed by the design and is of a quality equal to or better than the material, article or equipment identified by the drawings and specifications may be used if approval is secured in writing from the Architect/Engineer via addendum. The Contractor assumes all costs incurred as a result of using the offered material, article or equipment, on the Contractors part or on the part of other Contractors whose work is affected.

E. Voluntary add or deduct prices for alternate materials may be listed on the bid form. These items will not be used in determining the low bidder. This Contractor assumes all costs incurred as a result of using the offered material or equipment on the Contractors part or on the part of other Contractors whose work is affected.

F. All material substitutions requested after the final addendum must be listed as voluntary changes on the bid form.

1.16 PROJECT COMMISSIONING

A. The Contractor shall work with the Commissioning Agent (CxA) as described in Section 26 08 00 and provide all services as described in the Commissioning Plan.

PART 2 - PRODUCTS

2.1 GENERAL

A. All items of material having a similar function (e.g., safety switches, panelboards, switchboards, contactors, motor starters, dry type transformers) shall be of the same manufacturer unless specifically stated otherwise on drawings or elsewhere in specifications.

PART 3 - EXECUTION

3.1 JOBSITE SAFETY

A. Neither the professional activities of the Architect/Engineer, nor the presence of the Architect/Engineer or the employees and subconsultants at a construction site, shall relieve the Contractor and any other entity of their obligations, duties and responsibilities including, but not limited to, construction means, methods, sequence, techniques or procedures necessary for performing, superintending or coordinating all portions of the work of construction in accordance with the contract documents and any health or safety precautions required by any regulatory agencies. The Architect/Engineer and personnel have no authority to exercise any control over any construction contractor or other entity or their employees in connection with their work or any health or safety precautions. The Contractor is solely responsible for jobsite safety. The Architect/Engineer and the Architect/Engineer's consultants shall be indemnified and shall be made additional insureds under the Contractor's general liability insurance policy.

3.2 EXCAVATION, FILL, BACKFILL, COMPACTION

A. General:

1. Prior to the commencement of any excavation or digging, the Contractor shall verify all underground utilities with the regional utility locator. Provide prior notice to the locator before excavations. Contact information for most regional utility locaters can be found by calling 811.
2. The Contractor shall do all excavating, filling, backfilling, compacting, and restoration in connection with the work.

B. Excavation:

1. Make all excavations to accurate, solid, undisturbed earth, and to proper dimensions.
2. If excavations are carried in error below indicated levels, concrete of same strength as specified for the foundations or thoroughly compacted sand-gravel fill, as determined by the Architect/Engineer shall be placed in such excess excavations under the foundation. Place thoroughly compacted, clean, stable fill in excess excavations under slabs on grade, at the Contractor's expense.
3. Trim bottom and sides of excavations to grades required for foundations.
4. Protect excavations against frost and freezing.
5. Take care in excavating not to damage surrounding structures, equipment or buried pipe. Do not undermine footing or foundation.
6. Perform all trenching in a manner to prevent cave-ins and risk to workmen.

7. Where original surface is pavement or concrete, the surface shall be saw cut to provide clean edges and assist in the surface restoration.
8. If satisfactory bearing soil is not found at the indicated levels, immediately notify the Architect/Engineer or their representative, and do no further work until the Architect/Engineer or their representative gives further instructions.
9. Excavation shall be performed in all ground conditions, including rock, if encountered. Bidders shall visit the premises and determine the soil conditions by actual observations, borings, or other means. The cost of all such inspections, borings, etc., shall be borne by the bidder.
10. If a trench is excavated in rock, a compacted bed with a depth of 3" (minimum) of sand and gravel shall be used to support the conduit unless masonry cradles or encasements are used.
11. Mechanical excavation of the trench to line and grade of the conduit or to the bottom level of masonry cradles or encasements is permitted, unless otherwise indicated on the electrical drawings.
12. Mechanical excavation of the trench to line and grade where direct burial cables are to be installed is permitted provided the excavation is made to a depth to permit installation of the cable on a fine sand bed at least 3 inches deep.

C. Dewatering:

1. Furnish, install, operate and remove all dewatering pumps and pipes needed to keep trenches and pits free of water.

D. Underground Obstructions:

1. Known underground piping, conduit, feeders, foundations, and other obstructions in the vicinity of construction are shown on the drawings. Review all Bid Documents for all trades on the project to determine obstructions indicated. Take great care in making installations near underground obstructions.
2. If objects not shown on the drawings are encountered, remove, relocate, or perform extra work as directed by the Architect/Engineer.

E. Fill and Backfilling:

1. Utilities Bedding: Lay underground utilities on minimum of 6"sand bedding. Compact bedding under utilities smooth, with no sharp edges protruding, to protect the utilities from puncture. Shape bedding to provide continuous support for bells, joints, and barrels of utilities and for joints and fittings.
2. Envelope around utilities to 6" above utilities: Place and compact sand to a height of 6" over utilities in 6" layers. Each layer shall be placed, then carefully and uniformly tamped, to eliminate lateral or vertical displacement. After connection joints are made, any misalignment can be corrected by tamping backfill around the utilities.
3. Backfill from 6" above utilities to earthen grade: Place all backfill materials above the utilities in uniform layers not exceeding 6" deep. Each layer shall be placed, then carefully and uniformly tamped, to eliminate lateral or vertical displacement.
4. Backfill from 6" above utilities to below slabs or paved area: Where the fill and backfill will ultimately be under a building, floor or paving, each layer of backfill materials shall be compacted to 95% of the maximum density determined by AASHTO Designation T 99 or ASTM Designation D 698. Moisture content of soil at time of compaction shall not exceed plus or minus 2% of optimum moisture content determined by AASHTO T 99 or ASTM D 698 test.
5. Backfill over utilities under paved areas be 3/4" washed rock from utility bedding up to below pavement.
6. Backfill Materials: Native soil materials may be used as backfill if approved by the Geotechnical Engineer. Backfill material shall be free of rock or gravel larger than 3" in any dimension and shall be free of debris, waste, frozen materials, vegetation, high void content, and other deleterious materials. Water shall not be permitted to rise in unbackfilled trenches.
7. Dispose of excess excavated earth as directed.
8. Backfill all trenches and excavations immediately after installing utilities or removal of forms, unless other protection is provided.

9. Around piers and isolated foundations and structures, backfill and fill shall be placed and consolidated simultaneously on all sides to prevent wedge action and displacement. Fill and backfill materials shall be spread in 6 inch uniform horizontal layers with each layer compacted separately to required density.

F. Surface Restoration:

1. Where trenches are cut through existing graded, planted, or landscaped areas, the areas shall be restored to the original condition. Replace all planting removed or damaged to its original condition. A minimum of 6 inches of topsoil shall be applied where disturbed areas are to be seeded or sodded.
2. Concrete or asphalt type pavement, seal coat, rock, gravel or earth surfaces removed or damaged shall be replaced with comparable materials and restored to original condition.

3.3 ARCHITECT/ENGINEER OBSERVATION OF WORK

A. The contractor shall provide seven (7) calendar days' notice to the Architect/Engineer prior to:

1. Placing fill over underground and underslab utilities.
2. Covering exterior walls, interior partitions and chases.
3. Installing hard or suspended ceilings and soffits.

B. The Architect/Engineer will review the installation and provide a written report noting deficiencies requiring correction. The contractor's schedule shall account for these reviews and show them as line items in the approved schedule.

C. Above-Ceiling Final Observation:

1. All work above the ceilings must be complete prior to the Architect/Engineer's review. This includes, but is not limited to:

a. All junction boxes are closed and identified in accordance with Section 26 05 53 Electrical Identification.
b. Luminaires, including ceiling-mounted exit and emergency lights, are installed and operational.
c. Luminaire whips are supported above the ceiling.
d. Conduit identification is installed in accordance with Section 26 05 53 Electrical Identification.
e. Luminaires are suspended independently of the ceiling system when required by these contract documents.
f. All wall penetrations have been sealed.

2. To prevent the Above-Ceiling Final Observation from occurring too early, the Contractor shall review the status of the work and certify, in writing, that the work is ready for the Above-Ceiling Final Observation.
3. It is understood that if the Architect/Engineer finds the ceilings have been installed prior to this review and prior to seven days elapsing, the Architect/Engineer may not recommend further payments to the contractor until full access has been provided.

3.4 PROJECT CLOSEOUT

A. The following paragraphs supplement the requirements of Division 1.

B. Final Jobsite Observation:

1. To prevent the Final Jobsite Observation from occurring too early, the Contractor shall review the completion status of the project and certify that the job is ready for the final jobsite observation.

2. Attached to the end of this section is a typical list of items that represent the degree of job completeness expected prior to requesting a review. The Contractor shall sign the attached certification and return it to the Architect/Engineer so that the final observation can be scheduled.
3. It is understood that if the Architect/Engineer finds the job not ready for the final observation and additional trips and observations are required to bring the project to completion, the cost of the additional time and expenses incurred by the Architect/Engineer will be deducted from the Contractor's final payment.
4. Contractor shall notify Architect/Engineer 48 hours prior to installation of ceilings or lay-in ceiling tiles.

C. The following must be submitted before Architect/Engineer recommends final payment:

1. Operation and maintenance manuals with copies of approved shop drawings.
2. Record documents including reproducible drawings and specifications.
3. A report documenting the instructions given to the Owner's representatives complete with the number of hours spent in the instruction. The report shall bear the signature of an authorized agent of this Contractor and shall be signed by the Owner's representatives.
4. Provide spare parts, maintenance, and extra materials in quantities specified in individual specification sections. Deliver to project site and place in location as directed and submit receipt to Architect/Engineer.
5. Inspection and testing report by the fire alarm system manufacturer.
6. Start-up reports on all equipment requiring a factory installation or start-up.

D. Circuit Directories:

1. Provide custom typed circuit directory for each branch circuit panelboard. Label shall include equipment name or final approved room name, room number, and load type for each circuit (examples: SUMP SP-1 or ROOM 101 RECEPT). Revise directory to reflect circuit changes required to balance phase loads. Printed copies of the bid document panel schedules are not acceptable as circuit directories.

3.5 OPERATION AND MAINTENANCE MANUALS

A. General:

1. Provide (2) printed copies of O&M manuals to owners.
2. Provide warranties in separate binders dedicated to that purpose.
3. Provide an electronic copy of the O&M manuals as described below for Architect/Engineer's review and approval. The electronic copy shall be corrected as required to address the Architect/Engineer's comments. Once corrected, electronic copies and paper copies shall be distributed as directed by the Architect/Engineer.
4. Approved O&M manuals shall be completed and in the Owner's possession prior to Owner's acceptance and at least 10 days prior to instruction of operating personnel.

B. Electronic Submittal Procedures:

1. Distribution: Email the O&M manual as attachments to all parties designated by the Architect/Engineer.
2. Transmittals: Each submittal shall include an individual electronic letter of transmittal.
3. Format: Electronic submittals shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Submittals that are not legible will be rejected. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.
4. File Names: Electronic submittal file names shall include the relevant specification section number followed by a description of the item submitted, as follows. Where possible, include the transmittal as the first page of the PDF instead of using multiple electronic files.

   a. O&M file name: O&M.div26.contractor.YYYYMMDD
   b. Transmittal file name: O&Mtransmittal.div26.contractor.YYYYMMDD

5. File Size: Files shall be transmitted via a pre-approved method. Larger files may require an alternative transfer method, which shall also be pre-approved.
6. Provide the Owner with an approved copy of the O&M manual on compact discs (CD), digital video discs (DVD), or flash drives with a permanently affixed label, printed with the title "Operation and Maintenance Instructions", title of the project and subject matter of disc/flash drive when multiple disc/flash drives are required.
7. All text shall be searchable.
8. Bookmarks shall be used, dividing information first by specification section, then systems, major equipment and finally individual items. All bookmark titles shall include the nomenclature used in the construction documents and shall be an active link to the first page of the section being referenced.

C. Operation and Maintenance Instructions shall include:

1. Title Page: Include title page with project title, Architect, Engineer, Contractor, all subcontractors, and major equipment suppliers, with addresses, telephone numbers, website addresses, email addresses and point of contacts. Website URLs and email addresses shall be active links in the electronic submittal.
2. Table of Contents: Include a table of contents describing specification section, systems, major equipment, and individual items.
3. Copies of all final <u>approved</u> shop drawings and submittals. Include Architect's/Engineer's shop drawing review comments. Insert the individual shop drawing directly after the Operation and Maintenance information for the item(s) in the review form.
4. Copies of all factory inspections and/or equipment startup reports.
5. Copies of warranties.
6. Schematic wiring diagrams of the equipment that have been updated for field conditions. Field wiring shall have label numbers to match drawings.
7. Dimensional drawings of equipment.
8. Detailed parts lists with lists of suppliers.
9. Operating procedures for each system.
10. Maintenance schedule and procedures. Include a chart listing maintenance requirements and frequency.
11. Repair procedures for major components.
12. Replacement parts and service material requirements for each system and the frequency of service required.
13. Instruction books, cards, and manuals furnished with the equipment.
14. Include record drawings of the one-line diagrams for each major system. The graphic for each piece of equipment shown on the one-line diagram shall be an active link to its associated Operation & Maintenance data.
15. Copies of all panel schedules in electronic Microsoft Excel spreadsheet (.xlsx) file. Each panelboard shall be a separate tab in the workbook.

3.6 INSTRUCTING THE OWNER'S REPRESENTATIVE

A. Adequately instruct the Owner's designated representatives in the maintenance, care, and operation of the complete systems installed under this contract.

B. Provide verbal and written instructions to the Owner's representatives by FACTORY PERSONNEL in the care, maintenance, and operation of the equipment and systems.

C. The Owner has the option to make a video recording of all instructions. Coordinate schedule of instructions to facilitate this recording.

D. The instructions shall include:

1. Maintenance of equipment.
2. Start-up procedures for all major equipment.
3. Description of emergency system operation.

E. Notify the Architect/Engineer of the time and place for the verbal instructions to be given to the Owner's representative so a representative can be present if desired.

F. Minimum hours of instruction time for each item and/or system shall be as indicated in each individual specification section.

G. Operating Instructions:

1. Contractor is responsible for all instructions to the Owner's representatives for the electrical and specialized systems.
2. If the Contractor does not have staff that can adequately provide the required instructions, the Contractor shall include in the bid an adequate amount to reimburse the Owner for the Architect/Engineer to perform these services.

3.7 RECORD DOCUMENTS

A. Provide (2) printed copies of record documents to owners.

B. The following paragraphs supplement Division 1 requirements.

C. Maintain at the job site a separate and complete set of electrical drawings and specifications with all changes made to the systems clearly and permanently marked in complete detail.

D. Mark drawings and specifications to indicate approved substitutions; Change Orders, and actual equipment and materials used. All Change Orders, RFI responses, Clarifications and other supplemental instructions shall be marked on the documents. Record documents that merely reference the existence of the above items are not acceptable. Should this Contractor fail to complete Record Documents as required by this contract, this Contractor shall reimburse Architect/Engineer for all costs to develop record documents that comply with this requirement. Reimbursement shall be made at the Architect/Engineer's hourly rates in effect at the time of work.

E. Record changes daily and keep the marked drawings available for the Architect/Engineer's examination at any normal work time.

F. Upon completing the job, and before final payment is made, give the marked-up drawings to the Architect/Engineer.

G. Record actual routing of conduits exceeding 2 inches.

3.8 PAINTING

A. Paint all equipment that is marred or damaged prior to the Owner's acceptance. Paint and color shall match original equipment paint and shall be obtained from the equipment supplier if available. All equipment shall have a finished coat of paint applied unless specifically allowed to be provided with a prime coat only.

B. Equipment in finished areas that will be painted to match the room decor will be painted by others. Should this Contractor install equipment in a finished area after the area has been painted, the Contractor shall have the equipment and all its supports, hangers, etc., painted to match the room decor. Painting shall be performed as described in project specifications.

C. Equipment cabinets, casings, covers, metal jackets, etc., located in equipment rooms or concealed spaces, shall be furnished in standard finish, free from scratches, abrasions, chippings, etc.

D. Equipment in occupied spaces, or if standard to the unit, shall have a baked primer with baked enamel finish coat free from scratches, abrasions, chipping, etc. If color option is specified or is standard to the unit, verify with the Architect the color preference before ordering.

E. After surfaces have been thoroughly cleaned and are free of oil, dirt or other foreign matter, paint all raceway and equipment with the following:

1. Bare Metal Surfaces - Apply one coat of metal primer suitable for the metal being painted. Finish with two coats of Alkyd base enamel paint.
2. Plastic Surfaces - Paint plastic surfaces with two coats of semi-gloss acrylic latex paint.

3.9 ADJUST AND CLEAN

A. Thoroughly clean all equipment and systems prior to the Owner's final acceptance of the project.

B. Clean all foreign paint, grease, oil, dirt, labels, stickers, etc. from all equipment.

C. Remove all rubbish, debris, etc., accumulated during construction from the premises.

3.10 SPECIAL REQUIREMENTS

A. Coordinate the installation of all equipment, controls, devices, etc., with other trades to maintain clear access area for servicing.

B. Install all equipment to maximize access to parts needing service or maintenance. Review the final location, placement, and orientation of equipment with the Owner's representative prior to setting equipment.

C. Installation of equipment or devices without regard to coordination of access requirements and confirmation with the Owner's representative will result in removal and reinstallation of the equipment at the Contractor's expense.

D. Raceway and Cable Routing Restrictions: Raceways and cable are restricted from being routed in the following locations, unless serving the space or permitted by the authority having jurisdiction.

1. Elevator machine rooms and hoistways.
2. Exit enclosures.
3. Other areas restricted by code.
4. Technology, data, server rooms.
5. Fire pump and sprinkler rooms.
6. Normal power in emergency power equipment rooms: Limited to feeders and branch circuits serving the emergency power equipment located in the room.
7. Emergency power in normal power equipment rooms: Limited to feeders and branch circuits serving the normal power equipment located in the room.

3.11 INDOOR AIR QUALITY (IAQ) MAINTENANCE FOR OCCUPIED FACILITIES UNDER CONSTRUCTION

A. Within the Limits of Construction:

1. The Electrical Contractor shall coordinate all work with the contractor responsible for IAQ.
2. The means, methods and materials used by the Electrical Contractor shall be coordinated with the contractor responsible for IAQ and shall comply with the IAQ requirements set forth in Division 1 and Division 21/22/23 of these specifications.

B. Outside the Limits of Construction:

1. IAQ shall be the responsibility of the electrical contractor for work that is required outside the limits of construction.
2. The Electrical Contractor is responsible for the IAQ set forth in Division 1 and Division 21/22/23 of these specifications.

3. The Electrical Contractor shall review and coordinate all IAQ plans and procedures with the owner's IAQ representative.

3.12 SYSTEM STARTING AND ADJUSTING

A. The electrical systems shall be complete and operating. System startup, testing, adjusting, and balancing to obtain satisfactory system performance is the responsibility of the Contractor. This includes all calibration and adjustment of electrical controls, balancing of loads, troubleshooting and verification of software, and final adjustments that may be needed.

B. Complete all manufacturer-recommended startup procedures and checklists to verify proper equipment operation and does not pose a danger to personnel or property.

C. All operating conditions and control sequences shall be tested during the start-up period. Testing all interlocks, safety shut-downs, controls, and alarms.

D. The Contractor, subcontractors, and equipment suppliers shall have skilled technicians to ensure that all systems perform properly. If the Architect/Engineer is requested to visit the job site for trouble shooting, assisting in start-up, obtaining satisfactory equipment operation, resolving installation and/or workmanship problems, equipment substitution issues or unsatisfactory system performance, including call backs during the warranty period, through no fault of the design; the Contractor shall reimburse the Owner on a time and materials basis for services rendered at the Architect/Engineer's standard hourly rates in effect when the services are requested. The Contractor shall pay the Owner for services required that are product, installation or workmanship related. Payment is due within 30 days after services are rendered.

3.13 FIELD QUALITY CONTROL

A. General:

1. Conduct all tests required during and after construction. Submit test results in NETA format, or equivalent form, that shows the test equipment used, calibration date, tester's name, ambient test conditions, humidity, conductor length, and results corrected to 40°C.
2. Supply necessary instruments, meters, etc., for the tests. Supply competent technicians with training in the proper testing techniques.
3. All cables and wires shall be tested for shorts and grounds following installation and connection to devices. Replace shorted or grounded wires and cables.
4. Any wiring device, electrical apparatus or luminaire, if grounded or shorted on any integral "live" part, shall have all defective parts or materials replaced.
5. Test cable insulation of service and panel feeder conductors for proper insulation values. Tests shall include the cable, all splices, and all terminations. Each conductor shall be tested and shall test free of short circuits and grounds and have an insulation value not less than Electrical Code Standards. Take readings between conductors, and between conductors and ground.
6. If the results obtained in the tests are not satisfactory, make adjustments, replacements, and changes as needed. Then repeat the tests, and make additional tests, as the Architect/Engineer or authority having jurisdiction deems necessary.

B. Ground Resistance:

1. Provide a new grounding system for the new electrical entrance switchgear.

2. Conduct service ground resistance tests using an approved manufactured ground resistance meter. Submit to the Architect/Engineer a proposed test procedure including type of equipment to be used. (The conventional ohmmeter is not an acceptable device.)
3. Make ground resistance measurements during normal dry weather and not less than 48 hours after a rain.

4. If the ground resistance value obtained is more than the value set forth in Section 26 05 26, the following shall be done to obtain the value given:

   a. Verify that all connections in the service ground system are secure.
   b. Increase the depth to which ground rods are driven by adding section lengths to the rods and retest. If the resistance is still excessive increase the depth by adding an additional rod section and retest.
   c. If the resistance is still excessive, furnish and install additional ground rods, spaced not less than 20 feet from other ground rods unless otherwise noted on plans, and connect into the ground electrode system. Retest.
   d. Review results with the Architect/Engineer.

5. Before final payment is made to the Contractor submit a written report to the Architect/Engineer including the following:

   a. Date of test.
   b. Number of hours since the last rain.
   c. Soil condition at the time of the test in the ground electrode location. That is: dry, wet, moist, sand, clay, etc.
   d. Diagram of the test set-up showing distances between test equipment, ground electrode, auxiliary electrodes, etc.
   e. Make, model, and calibration date of test equipment.
   f. Tabulation of measurements taken and calculations made.

C. Ground-Fault Equipment Performance Testing:

1. Test: Perform ground-fault performance testing when system is installed. The test process shall use primary current injection per manufacturer instruction and procedures. Perform test for the following:

   a. Service disconnects
   b. Solid state molded case circuit breakers and solid-state insulated case circuit breakers equipped with ground fault protection.
   c. Fusible switches with ground fault relay protection.
   d. Outside branch circuits and feeders.
   e. Code required.

2. Report: Provide copy of test result report with Operation and Maintenance manuals. Provide report to Authority Having Jurisdiction when requested.

D. Arc Energy Reduction Equipment Performance Testing:

1. Test: Perform arc energy protection performance testing when system is installed. The test process shall use primary current injection or approved method per manufacturer instructions and procedures. Perform test for the following:

   a. All arc energy reduction systems installed.

2. Provide arc flash rating signage at electrical rooms.
3. Provide arc flash approach distance markings on floors around electrical equipment.

4. Report: Provide copy of test result report with Operation and Maintenance manuals. Provide report to Authority Having Jurisdiction when requested.

E. Other Equipment:

1. Give other equipment furnished and installed by the Contractor all standard tests normally made to assure that the equipment is electrically sound, all connections properly made, phase rotation correct, fuses and thermal elements suitable for protection against overloads, voltage complies with equipment nameplate rating, and full load amperes are within equipment rating.

F. If any test results are not satisfactory, make adjustments, replacements and changes as needed and repeat the tests and make additional tests as the Architect/Engineer or authority having jurisdiction deem necessary.

READINESS CERTIFICATION PRIOR TO FINAL JOBSITE OBSERVATION

To prevent the final job observation from occurring too early, we require that the Contractor review the completion status of the project and, by copy of this document, certify that the job is indeed ready for the final job observation. The following is a typical list of items that represent the degree of job completeness expected prior to your requesting a final job observation.

1. Penetrations of fire-rated construction fire sealed in accordance with specifications.
2. Electrical panels have typed circuit identification.
3. Smoke and fire/smoke dampers are wired and have been tested.
4. Per Section 26 05 00, cable insulation test results have been submitted.
5. Per Section 26 05 00, medium voltage testing report has been submitted.
6. Per Section 26 05 00, ground resistance test results have been submitted.
7. Operation and Maintenance manuals have been submitted as per Section 26 05 00.
8. Bound copies of approved shop drawings have been submitted as per Section 26 05 00.
9. Report of instruction of Owner's representative has been submitted as per Section 26 05 00.
10. Fire alarm inspection and testing report has been submitted as per Sections 26 05 00 and 28 31 00.
11. Start-up reports from factory representative have been submitted as per Section 26 05 00.

Accepted by:

Prime Contractor ____

By __________________________________ Date ___________________

Upon Contractor certification that the project is complete and ready for a final job observation, we require the Contractor to sign this agreement and return it to the Architect/Engineer so that the final observation can be scheduled.

It is understood that if the Architect/Engineer finds the job not ready for the final observation and that additional trips and observations are required to bring the project to completion, the costs incurred by the Architect/Engineers for additional time and expenses will be deducted from the Contractor's contract retainage prior to final payment at the completion of the job.

END OF SECTION 26 05 00

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SECTION 26 05 03 - THROUGH PENETRATION FIRESTOPPING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Through-Penetration Firestopping.

1.2 QUALITY ASSURANCE

A. Manufacturer: Company specializing in manufacturing products specified in this Section.

B. Installer: Individuals performing work shall be certified by the manufacturer of the system selected for installation.

1.3 REFERENCES

A. UL 263 - Fire Tests of Building Construction and Materials

B. UL 723 - Surface Burning Characteristics of Building Materials

C. ANSI/UL 1479 - Fire Tests of Through Penetration Firestops

D. UL 2079 - Tests for Fire Resistance of Building Joint Systems

E. UL Fire Resistance Directory Through Penetration Firestop Systems (XHEZ)

F. Intertek / Warnock Hersey - Directory of Listed Products

G. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials

H. ASTM E814 - Standard Test Method for Fire Tests of Through-Penetration Firestops

I. The Building Officials and Code Administrators National Building Code

J. 1997 Uniform Building Code

K. 2015 International Building Code

1.4 SUBMITTALS

A. Submit under provisions of Section 26 05 00.

B. Submit Firestopping Installers Certification for all installers on the project.

C. Shop Drawings: Submit for each condition requiring firestopping. Include descriptions of the specific penetrating item, actual wall/floor construction, manufacturer's installation instructions, and UL or Interek / Warnock Hersey Assembly number.

D. Through-Penetration Firestop System Schedule: Indicate locations of each through-penetration firestop system, along with the following information:

1. Types of penetrating items.
2. Types of constructions penetrated, including fire-resistance ratings and, where applicable, thicknesses of construction penetrated.
3. Through-penetration firestop systems for each location identified by firestop design designation of qualified testing and inspecting agency.
4. F ratings for each firestop system.

E. Maintain a notebook on the job site at all times that contains copies of approved submittals for all through penetration firestopping to be installed. Notebook shall be made available to the Authority Having Jurisdiction at their request and turned over to the Owner at the end of construction as part of the O&M Manuals.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store, protect and handle products on site. Accept material on site in factory containers and packing. Inspect for damage. Protect from deterioration or damage due to moisture, temperature changes, contaminants, or other causes. Follow manufacturer's instructions for storage.

B. Install material prior to expiration of product shelf life.

1.6 PERFORMANCE REQUIREMENTS

A. General: For penetrations through the following fire-resistance-rated constructions, including both empty openings and openings containing penetrating items, provide through-penetration firestop systems that are produced and installed to resist spread of fire according to requirements indicated, resist passage of smoke and other gases, and maintain original fire-resistance rating of construction penetrated.

1. Fire-resistance-rated walls including fire partitions, fire barriers, and smoke barriers.
2. Fire-resistance-rated horizontal assemblies including floors, floor/ceiling assemblies, and ceiling membranes of roof/ceiling assemblies.

B. For through-penetration firestop systems exposed to light, traffic, moisture, or physical damage, provide products that, after curing, do not deteriorate when exposed to these conditions both during and after construction.

C. For through-penetration firestop systems exposed to view, provide products with flame-spread and smoke-developed indexes of less than 25 and 450, respectively, as determined per ASTM E 84.

D. For through-penetration firestop systems in air plenums, provide products with flame-spread and smoke-developed indexes of less than 25 and 50, respectively, as determined per ASTM E 84.

1.7 WARRANTY

A. Provide one year warranty on parts and labor.

B. Warranty shall cover repair or replacement of firestop systems which fail in joint adhesion, cohesion, abrasion resistance, weather resistance, extrusion resistance, migration resistance, stain resistance, general durability, or appear to deteriorate in any manner not clearly specified by the manufacturer as an inherent quality of the material.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Products: Subject to compliance with requirements, provide one of the through-penetration firestop systems indicated for each application that are produced by one of the following manufacturers. All firestopping systems installed shall be provided by a single manufacturer.

1. 3M; Fire Protection Products Division
2. Hilti, Inc.
3. RectorSeal Corporation, Metacaulk
4. Tremco; Sealant/Weatherproofing Division
5. Johns-Manville
6. Specified Technologies Inc. (S.T.I.)
7. Spec Seal Firestop Products
8. AD Firebarrier Protection Systems
9. Wiremold/Legrand: FlameStopper
10. Dow Corning Corp
11. Fire Trak Corp
12. International Protective Coating Corp

2.2 THROUGH PENETRATION FIRESTOP SYSTEMS

A. Provide materials and systems classified by or listed by Intertek / Warnock Hersey to provide firestopping equal to time rating of construction being penetrated.

B. All firestopping materials shall be free of asbestos, lead, PCB's, and other materials that would require hazardous waste removal.

C. Firestopping shall be flexible to allow for normal penetrating item movement due to expansion and contraction.

D. Provide firestopping systems capable of supporting floor loads where systems are exposed to possible floor loading or traffic.

E. Provide firestopping systems allowing continuous insulation for all insulated pipes.

F. Provide firestopping systems classified by UL or listed by Intertek / Warnock Hersey for penetrations through all fire rated construction. Firestopping systems shall be selected from the UL or listed by Intertek / Warnock Hersey Fire Resistance Directory Category XHEZ based on substrate construction and penetrating item size and material and shall fall within the range of numbers listed:

1. Combustible Framed Floors and Chase Walls - 1 or 2 Hour Rated:

a. F Rating = Floor/Wall Rating
b. L Rating = Penetrations in Smoke Barriers

Penetrating Item	UL System No.
No Penetrating Item	FC 0000-0999*
Metallic Pipe or Conduit	FC 1000-1999
Non-Metallic Pipe or Conduit	FC 2000-2999
Electrical Cables	FC 3000-3999
Cable Trays	FC 4000-4999
Insulated Pipes	FC 5000-5999
Bus Duct and Misc. Electrical	FC 6000-6999
Duct without Damper and Misc. Mechanical	FC 7000-7999
Multiple Penetrations	FC 8000-8999

*Alternate method of firestopping is patching opening to match original

Penetrating Item	UL System No.
rated construction.	

2. Non-Combustible Framed Walls - 1 or 2 Hour Rated:

   a. F Rating = Wall Rating
   b. L Rating = Penetrations in Smoke Barriers

Penetrating Item	UL System No.
No Penetrating Item	WL 0000-0999*
Metallic Pipe or Conduit	WL 1000-1999
Non-Metallic Pipe or Conduit	WL 2000-2999
Electrical Cables	WL 3000-3999
Cable Trays	WL 4000-4999
Insulated Pipes	WL 5000-5999
Bus Duct and Misc. Electrical	WL 6000-6999
Duct without Damper and Misc. Mechanical	WL 7000-7999
Multiple Penetrations	WL 8000-8999
*Alternate method of firestopping is patching opening to match original rated construction.	

3. Concrete or Masonry Floors and Walls - 1 or 2 Hour Rated:

   a. F Rating = Wall/Floor Rating
   b. L Rating = Penetrations in Smoke Barriers

Penetrating Item	UL System No.
No Penetrating Item	CAJ 0000-0999*
Metallic Pipe or Conduit	CAJ 1000-1999
Non-Metallic Pipe or Conduit	CAJ 2000-2999
Electrical Cables	CAJ 3000-3999
Cable Trays	CAJ 4000-4999
Insulated Pipes	CAJ 5000-5999
Bus Duct and Misc. Electrical	CAJ 6000-6999
Duct without Damper and Misc. Mechanical	CAJ 7000-7999
Multiple Penetrations	CAJ 8000-8999
*Alternate method of firestopping is patching opening to match original rated construction.	

G. Any opening in walls or floors not covered by the listed series of numbers shall be coordinated with the firestopping manufacturer.

H. Any openings in floors or walls not described in the UL or listed by Intertek / Warnock Hersey Fire Resistance Directory, or outlined in manufacturer's information shall be sealed in a manner agreed upon by the Firestopping Manufacturer, Owner, and the Authority Having Jurisdiction.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Ensure all surfaces that contact seal materials are free of dirt, dust, grease, oil, rust, or loose materials. Clean and repair surfaces as required. Remove laitance and form-release agents from concrete.

B. Ensure substrate and penetrating items have been permanently installed prior to installing firestopping systems. Ensure penetrating items have been properly spaced and have proper clearance prior to installing firestopping systems.

C. Surfaces to which sealing materials are to be installed must meet the selected UL or Intertek / Warnock Hersey system substrate criteria.

D. Prime substrates where recommended in writing by through-penetration firestop system manufacturer. Confine primer to area of bond.

3.2 INSTALLATION

A. In existing construction, provide firestopping of openings prior to and after installation of penetrating items. Remove any existing coatings on surfaces prior to firestopping installation. Temporary firestopping shall consist of packing openings with fire resistant mineral wool for the full thickness of substrate, or an alternate method approved by the Authority Having Jurisdiction. All openings shall be temporarily firestopped immediately upon their installation and shall remain so until the permanent UL or listed by Intertek / Warnock Hersey listed firestopping system is installed.

B. Install penetration seal materials in accordance with printed instructions of the UL or Intertek / Warnock Hersey Fire Resistance Directory and with the manufacturer's printed application instructions.

C. Install dams as required to properly contain firestopping materials within openings and as required to achieve required fire resistance rating. Remove combustible damming after appropriate curing.

3.3 CLEANING AND PROTECTING

A. Clean excess fill materials adjacent to openings as Work progresses by methods and with cleaning materials that are approved in writing by through-penetration firestop system manufacturers and that do not cause damage.

B. Provide final protection and maintain conditions during and after installation that ensure that through-penetration firestop systems are without damage or deterioration at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, remove damaged or deteriorated through-penetration firestop systems immediately and install new materials to produce systems complying with specified requirements.

3.4 IDENTIFICATION

A. Provide and install labels adjacent to each firestopping location. Label shall be provided by the firestop system supplier and contain the following information in a contrasting color:

1. The words "Warning - Through Penetration Firestop System - Do Not Disturb. Notify Building Management of Any Damage."
2. Firestop System Supplier; UL or listed by Intertek / Warnock Hersey system number; date installed; contractor name and phone number; manufacturer's representative name, address, and phone number.

3.5 INSPECTION

A. All penetrations shall be inspected by the manufacturer's representative to ensure proper installation.

B. Access to firestop systems shall be maintained for examination by the Authority Having Jurisdiction at their request.

C. Proceed with enclosing through-penetration firestop system with other construction only after inspection reports are issued and firestop installations comply with requirements.

D. The contractor shall allow for visual destructive review of 5% of installed firestop systems (minimum of one) to prove compliance with specifications and manufacturer's instructions and details. Destructive system removal shall be performed by the contractor and witnessed by the Architect/Engineer and manufacturer's factory representative. The Architect/Engineer shall have sole discretion of which firestop system installations will be reviewed. The contractor is responsible for all costs associated with this requirement including labor and material for removing and replacing the installed firestop system. If any firestop system is found to not be installed per manufacturer's specific instructions and details, all firestop systems are subject to destructive review and replacement at the Architect/Engineer's discretion and the contractor's expense.

END OF SECTION 26 05 03

SECTION 26 05 05 - ELECTRICAL DEMOLITION FOR REMODELING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Electrical demolition

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Materials and equipment for patching and extending work shall be as specified in individual Sections.

PART 3 - EXECUTION

3.1 EXAMINATION

A. THE DRAWINGS ARE INTENDED TO INDICATE THE SCOPE OF WORK REQUIRED AND DO NOT INDICATE EVERY BOX, CONDUIT, OR WIRE THAT MUST BE REMOVED. THE CONTRACTOR SHALL VISIT THE SITE PRIOR TO SUBMITTING A BID AND VERIFY EXISTING CONDITIONS.

B. Where walls, ceilings, structures, etc., are indicated as being removed on general or electrical drawings, the Contractor shall be responsible for the removal of all electrical equipment, devices, fixtures, raceways, wiring, systems, etc., from the removed area.

C. Where ceilings, walls, structures, etc., are temporarily removed and replaced by others, this Contractor shall be responsible for the removal, storage, and replacement of equipment, devices, fixtures, raceways, wiring, systems, etc.

D. Where mechanical or technology equipment is indicated as being removed on electrical, mechanical, or technology drawings, the Contractor shall be responsible for disconnecting the equipment and removing all starters, VFD, controllers, electrical equipment, raceways, wiring, etc. associated with the device.

E. Verify that abandoned wiring and equipment serve only abandoned equipment or facilities. Extend conduit and wire to facilities and equipment that will remain in operation following demolition. Extension of conduit and wire to equipment shall be compatible with the surrounding area. Extended conduit and conductors to match existing size and material.

F. Coordinate scope of work with all other Contractors and the Owner at the project site. Schedule removal of equipment and electrical service to avoid conflicts.

G. Bid submittal shall mean the Contractor has visited the project site and has verified existing conditions and scope of work.

3.2 PREPARATION

A. The Contractor shall obtain approval from the Owner before turning off power to circuits, feeders, panels, etc. Coordinate all outages with Owner.

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. Assume all equipment and systems must remain operational unless specifically noted otherwise on drawings.

C. Disconnect electrical systems in walls, floors, structures, and ceilings scheduled for removal.

D. Existing Electrical Service: Maintain existing system in service until new system is complete and ready for service. Disable system only to make switchovers and connections. Obtain permission from Owner at least t 72 hours before partially or completely disabling system. Minimize outage duration.

E. Existing Fire Alarm System: Maintain existing system in service until new system is accepted. Disable system only to make switchovers and connections. Obtain permission from Owner at least 72 hours before partially or completely disabling system. Minimize outage duration. Provide a watchman to make required premise observations during all outages, requirements as dictated by codes and Owner's insurance carrier.

3.3 DEMOLITION AND EXTENSION OF EXISTING ELECTRICAL WORK

A. Demolish and extend existing electrical work under provisions of Division 1 of Specifications and this Section.

B. Remove, relocate, and extend existing installations to accommodate new construction.

C. Remove abandoned wiring and raceway to source of supply. Existing conduit in good condition may be reused in place by including an equipment ground conductor in reused conduit. Reused conduit and boxes shall have supports revised to meet current codes. Relocating conduit shall not be allowed.

D. Remove exposed abandoned raceway, including abandoned raceway above accessible ceiling finishes. Cut raceway flush with walls and floors, and patch surfaces. Remove all associated clamps, hangers, supports, etc. associated with raceway removal.

E. Disconnect and remove outlets and devices that are to be demolished. Remove outlet or devices' associated back box, supports, and conduit and conductors back to source. Patch opening created from removal of device to match surrounding finishes.

F. Disconnect and remove abandoned panelboards and distribution equipment.

G. Disconnect and remove electrical devices and equipment serving utilization equipment that has been removed.

H. Disconnect and remove abandoned luminaires. Remove brackets, stems, hangers, and other accessories. Ballasts in light fixtures installed prior to 1980 shall be incinerated in EPA approved incinerator or disposed of in EPA certified containers and deposited in an EPA landfill certified for PCB disposal or recycled by permitted ballast recycler. Punctured or leaking ballasts must be disposed of according to Federal Regulations under the Toxic Substance Control Act. Provide Owner and Architect/Engineer with a Certificate of Destruction to verify proper disposal.

I. Repair adjacent construction and finishes damaged during demolition and extension work. Patch openings to match existing surrounding finishes.

J. Maintain access to existing electrical installations that remain active. Modify installation or provide junction boxes and access panel as appropriate.

K. Extend existing installations using materials and methods compatible with existing electrical installations, or as specified. Extended conduit and conductors to match existing size and material.

L. HID and fluorescent lamps, determined by the Toxicity Characteristic Leachate procedure (TCLP), to be hazardous waste shall be disposed of in an EPA-permitted hazardous waste disposal facility or by a permitted lamp recycler.

M. Regulatory Requirements: Comply with governing EPA notification regulations before beginning demolition. Comply with hauling and disposal regulations of authorities having jurisdiction.

N. Floor slabs may contain conduit systems. This Contractor is responsible for taking any measures required to ensure no conduits or other services are damaged. This includes x-ray or similar non-destructive means. Where conduit is in concrete slab, cut conduit flush with floor, pull out conductors, and plug conduit ends.

O. This Contractor is responsible for all costs incurred in repair, relocations, or replacement of any cables, conduits, or other services if damaged without proper investigation.

3.4 CLEANING AND REPAIR

A. Clean and repair existing materials and equipment that remain or are to be reused.

B. ELECTRICAL ITEMS (E.G., LIGHTING FIXTURES, RECEPTACLES, SWITCHES, CONDUIT, WIRE, ETC.) REMOVED AND NOT RELOCATED REMAIN THE PROPERTY OF THE OWNER. CONTRACTOR SHALL PLACE ITEMS RETAINED BY THE OWNER IN A LOCATION COORDINATED WITH THE OWNER. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE DISPOSAL OF MATERIAL THE OWNER DOES NOT WANT.

3.5 INSTALLATION

A. Install relocated materials and equipment under the provisions of Division 1 of Specifications.

END OF SECTION 26 05 05

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SECTION 26 05 13 - WIRE AND CABLE

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Building wire

B. Cabling for remote control, signal, and power limited circuits

C. Fire rated and circuit integrity (CI) cable and assemblies

1.2 RELATED WORK

A. Section 26 05 53 - Electrical Identification: Refer to electrical identification for color and identification labeling requirements.

1.3 REFERENCES

A. NEMA WC 70 - Power Cables Rated 2,000V or Less for the Distribution of Electrical Energy

B. NFPA 70 - National Electrical Code (NEC)

C. UL 44 - Thermoset-Insulated Wires and Cables

D. UL 83 - Thermoplastic-Insulated Wires and Cables

E. UL 854 - Service-Entrance Cables

F. UL 1581 - Standard for Electrical Wires, Cables, and Flexible Cords

G. UL 2196 - Fire Resistive, Fire Resistant and Circuit Integrity Cables

PART 2 - PRODUCTS

2.1 BUILDING WIRE

A. Feeders and Branch Circuits 8 AWG and larger: Copper, stranded conductor, 600-volt insulation, THHN/THWN or XHHW-2.

B. Feeders and Branch Circuits 8 AWG and larger in Underground Conduit: Copper, stranded conductor, 600-volt insulation, THWN or XHHW-2.

C. Feeders and Branch Circuits 10 AWG and Smaller: Copper, solid or stranded conductor, 600-volt insulation, THHN/THWN, unless otherwise noted on the drawings. Aluminum, compact stranded conductor is not acceptable for feeder and branch circuits 6 AWG and smaller.

D. Motor Feeder from Variable Frequency Drives: Copper conductor, 600-volt XHHW-2 insulation, stranded conductor, unless otherwise noted on the drawings. Three conductor stranded copper, 600-volt XHHW-2 insulation, with copper ground and overall helical copper tape shield. Shield shall be terminated at both ends of cable with an approved termination.

E. Control Circuits: Copper, stranded conductor 600-volt insulation, THHN/THWN.

F. Aluminum conductors are not to be used for feeds to motor loads.

G. Each 120 and 277-volt branch circuit shall have a dedicated neutral conductor. Neutral conductors shall be considered current-carrying conductors for wire derating.

2.2 CABLING FOR REMOTE CONTROL, SIGNAL, AND POWER LIMITED CIRCUITS

A. Wire for the following specialized systems shall be as designated on the drawings, or elsewhere in these specifications. If not designated on the drawings or specifications, the system manufacturer's recommendations shall be followed.

1. Fire alarm
2. Low voltage switching and lighting control
3. Electronic control
4. Other specialized cabling, signal, and power limited cabling. Refer to the appropriate Division 23, 27, or 28 requirements; including, but not limited, to the following:

    a. Building Automation Systems and Controls, Division 23.
    b. Information Technology Backbone and Horizontal Cabling, Division 27.
    c. Sound Masking Paging Systems, Professional Audio/Video, Division 27.
    d. Central Clock, Division 27.
    e. Distributed Cellular Antenna Systems, Division 27.
    f. Distributed Antenna System (First Responder], Division 28.
    g. Electronic Access Control, Intrusion Detection Systems, Video Surveillance, Division 28.
    h. Rescue Assistance Communication System, Division 28.

B. Control Cable for Class 1 Remote Control and Signal Circuits: Copper conductor, 600-volt insulation, rated 60°C, individual conductors twisted together, shielded, and covered with a PVC jacket.

C. Control Cable for Class 2 or Class 3 Remote Control and Signal Circuits: Copper conductor, 300-volt insulation, rated 60°C, individual conductors twisted together, shielded, and covered with a PVC jacket; UL listed.

D. Plenum Cable for Class 2 or Class 3 Remote Control and Signal Circuits: Copper conductor, 300-volt insulation, rated 60°C, individual conductors twisted together, shielded, and covered with a nonmetallic jacket; UL listed for use in air handling ducts, hollow spaces used as ducts, and plenums.

2.3 FIRE-RATED AND CIRCUIT INTEGRITY (CI) CABLE AND ASSEMBLIES

A. Properties and requirements of fire rated cables and assemblies:

1. 2HR fire rated for horizontal and vertical installations.

B. Acceptable fire-rated cables and listed assemblies:

1. Feeder assembly located outside the structure (example: below finished grade), rated metal stud and drywall enclosure, or encased in concrete; minimum 2 inches of concrete).
2. Exothermal Mat Material: Raceway / Cable protected with exothermic mat material, UL listed.

    a. Install per manufacturer guidelines and requirements. Apply appropriate quantity of wrapped layers of material as required to achieve rating.
    b. Contractor shall upsize cable / wiring / raceway sizes as required for derating.

c. Provide cable / wire ampacity derating calculations for each application, reference manufacturer for additional information, document and submit derated calculations as a shop drawing submittal for approval prior to installation. Minimum cable / wire derating shall be:

1) Individual conduit raceways (less than or equal to 4" trade size): 10%.
2) Parallel conduit raceways associated with the same feeder and protected by a common installation assembly: 15%.
3) Cable tray raceway: 50%.

d. Manufacturer:

1) 3M Interam Endothermic Mat
2) Or submitted for engineer review prior to bid.

3. Mineral Insulated Cables: Copper conductor, 600-volt insulation, rated 90°C, Type MI.

a. Manufacturer:

1) Raychem Pyrotenax MI

4. MC Cable: Copper conductor, 600V thermoset, low smoke zero halogen silicone rubber insulation, continuously welded corrugated copper armor for equipment grounding conductor, rated 90°C, UL listed 2196. MC fire rated cable shall not be used for branch circuits that required redundant equipment ground paths per code.

a. Manufacturers:

1) VITALink MC
2) Draka Lifeline MC Series

5. Fire rated cable in EMT or IMC raceway: Copper conductor, 300-volt or ethernet power-limited circuit cables low smoke zero halogen (LSZH), rated 105°C. Assembly including raceway shall be UL listed 2196 and UL circuit integrity (FHIT).

a. Manufacturers:

1) VITALINK CI/CIC or ethernet series
2) Draka RHW-2 EMT Series

PART 3 - EXECUTION

3.1 WIRE AND CABLE INSTALLATION SCHEDULE

A. Above Accessible Ceilings:

1. Building wire shall be installed in raceway.
2. Metal clad cable, Type MC, 1/2" size with minimum #12 conductors and ground, shall be allowed for flexible whips to individual luminaires on non-essential circuits. The flexible whips shall be between 18" to 72" in length per Electrical Code.

B. All Other Locations: Building wire in raceway.

C. Above Grade: All conductors installed above grade shall be type "THHN".

D. Underground or In Slab: All conductors shall be type "THWN".

E. Low Voltage Cable (less than 100 volts): Low voltage cables in ducts, plenums, and other air handling spaces shall be plenum listed. Low voltage cables in non-accessible areas shall be installed in conduit. Low voltage cable may be installed without conduit in accessible areas using the following types of cable supports. Cable support types/systems shall comply with the warranty requirements of the low voltage cable manufacturer.

1. J-hooks
2. Bridle rings with saddle supports

3.2 CONTRACTOR CHANGES

A. The basis of design is copper conductors installed in raceway based on ambient temperature of 30°C, NEC Table 310.16 (2011 - 2017 edition 310.15(B)(16)). Service entrance and fire pump feeder conductors are based on copper conductor installed in underground electrical ducts, NEC Table B.2(7) (2011 - 2017 edition Table B310.15(B)(2)(7); 2008 or later edition B.301.7) or calculated in accordance with Annex B Application Information for Ampacity Calculation.

B. The Contractor shall be responsible for derating and sizing conductors and conduits to equal or exceed the ampacity of the basis of design circuits, if he/she chooses to use methods or materials other than the basis of design.

C. Record drawing shall include the calculations and sketches.

3.3 GENERAL WIRING METHODS

A. Use no wire smaller than 12 AWG for power and lighting circuits, and no smaller than 14 AWG for control wiring.

B. Use no wire smaller than 18 AWG for low voltage control wiring below 100 volts.

C. Use 10 AWG conductor for 20 ampere, 120-volt branch circuit home runs longer than 75 feet, and for 20 ampere, 277-volt branch circuit home runs longer than 200 feet.

D. The ampacity of multiple conductors in one conduit shall be derated per the Electrical Code. In no case shall more than 4 conductors be installed in one conduit to such loads as motors larger than 1/4 HP, panelboards, motor control centers, etc.

E. Where installing parallel feeders, place an equal number of conductors for each phase of a circuit in same raceway or cable.

F. Splice only in junction or outlet boxes.

G. Neatly train and lace wiring inside boxes, equipment, and panelboards.

H. Make conductor lengths for parallel circuits equal.

I. All conductors shall be continuous in conduit from last outlet to their termination.

J. Terminate all spare conductors on terminal blocks, and label the spare conductors.

K. Cables or wires shall not be laid out on the ground before pulling.

L. Cables or wires shall not be dragged over earth or paving.

M. Care shall be taken so as not to subject the cable or wire to high mechanical stresses that would cause damage to the wire and cable.

N. At least six (6)-inch loops or ends shall be left at each outlet for installation connection of luminaires or other devices.

O. All wires in outlet boxes not connected to fixtures or other devices shall be rolled up, spliced if continuity of circuit is required, and insulated.

3.4 WIRING INSTALLATION IN RACEWAYS

A. Pull all conductors into a raceway at the same time. Use UL listed wire pulling lubricant for pulling 4 AWG and larger wires.

B. Install wire in raceway after interior of building has been physically protected from the weather and all mechanical work likely to injure conductors has been completed.

C. Pulling shall be continuous without unnecessary stops and starts with wire or cable only partially through raceway.

D. Where reels of cable or wire are used, they shall be set up on jacks close to the point where the wire or cable enters the conduit or duct so that the cable or wire may be unreeled and run into the conduit or duct with a minimum of change in the direction of the bend.

E. Conductors shall not be pulled through conduits until plastering or masonry work is completed and conduits are free from moisture. Care shall be taken so that long pulls of wire or pulls around several bends are not made where the wire may be permanently stretched and the insulation damaged.

F. Only nylon rope shall be permitted to pull cables into conduit and ducts.

G. Completely and thoroughly swab raceway system before installing conductors.

H. Conductor Supports in Vertical Raceways:

1. Support conductors in vertical raceways in accordance with the Electrical Code Spacing of Conductors Supports.
2. Supports shall be of insulated wedge type (OZ Gedney Type S, or equal) and installed in a tapered insulated bushing fitting or a metal woven mesh with a support ring that fits inside conduit fitting installed in an accessible junction box (Hubbell Kellems support grip or equal).

3.5 CABLE INSTALLATION

A. Provide protection for exposed cables where subject to damage.

B. Use suitable cable fittings and connectors.

C. Run all open cable parallel or perpendicular to walls, ceilings, and exposed structural members. Follow the routing as illustrated on the drawings as closely as possible. Cable routing on drawings scaled 1/4"=1'-0" or less shall be considered diagrammatical, unless noted otherwise. The correct routing, when shown diagrammatically, shall be chosen by the Contractor based on information in the contract documents; in accordance with the manufacturer's written instructions, applicable codes, the NECA's "Standard of Installation", recognized industry standards; and coordinated with other contractors.

D. Open cable shall be supported by the appropriate size J-hooks or other means if called for on the drawings. Wire and cable from different systems shall not be installed in the same J-hook. J-hooks shall be sized with 20% spare capacity. J-hooks shall provide proper bend radius support for data cable and fiber cables.

E. Open cable installed above suspended ceilings shall not rest on the suspended ceiling construction, nor utilize the ceiling support system for wire and cable support.

F. J-hook support spans shall be based on the smaller of the manufacturer's load ratings and code requirements. In no case shall horizontal spans exceed 5 feet and vertical spans exceed 4 feet. All J-hooks shall be installed where completely accessible and not blocked by piping, ductwork, inaccessible ceilings, etc. J-hooks shall be independently rigidly attached to a structural element. J-hooks shall be installed to provide 2" horizontal separation and 6" vertical separation between systems.

G. Open cable shall only be installed where specifically shown on the drawings, or permitted in these specifications.

3.6 FIRE-RATED CABLE AND ASSEMBLY INSTRUCTIONS

A. Terminations of the fire-rated cable must be outside of the fire zone.

B. Fire-rated cable shall be installed according to the manufacturer's instructions, recommendations, and UL listing.

C. Route fire-rated cable and assemblies separate from other feeders and distribution. Install cable and assemblies in locations protected from physical damage.

D. Refer to Electrical Identification Section 26 05 53 for specific identification requirements.

3.7 WIRING CONNECTIONS AND TERMINATIONS

A. Splice and tap only in accessible junction boxes.

B. Use solderless, tin-plated copper, compression terminals (lugs) applied with circumferential crimp for conductor terminations, 8 AWG and larger.

C. Use solderless, tin-plated, compression terminals (lugs) applied with indenter crimp for copper conductor terminations, 10 AWG and smaller.

D. Use solderless pressure connectors with insulating covers for copper wire splices and taps, 8 AWG and smaller. For 10 AWG and smaller, use insulated spring wire connectors with plastic caps.

E. Use compression connectors applied with circumferential crimp for conductor splices and taps, 6 AWG and larger. Tape uninsulated conductors and connectors with electrical tape to 150 percent of the insulation value of conductor.

F. Thoroughly clean wires before installing lugs and connectors.

G. Make splices, taps and terminations to carry full ampacity of conductors without perceptible temperature rise.

H. Phase Sequence: All apparatus shall be connected to operate in the phase sequence A-B-C representing the time sequence in which the phase conductors so identified reach positive maximum voltage.

I. As a general rule, applicable to switches, circuit breakers, starters, panelboards, switchgear and the like, the connections to phase conductors are intended thus:

1. Facing the front and operating side of the equipment, the phase identification shall be:

a. Left to Right - A-B-C
b. Top to Bottom - A-B-C

J. Connection revisions as required to achieve correct rotation of motors shall be made at the load terminals of the starters or disconnect switches.

3.8 FIELD QUALITY CONTROL

A. Field inspection and testing will be performed under provisions of Division 1.

B. Building Wire and Power Cable Testing: Perform an insulation-resistance test on each conductor with respect to ground and adjacent conductors. Test shall be made by means of a low-resistance ohmmeter, such as a "Megger". The applied potential shall be 500 volts dc for 300 volt rated cable and 1000 volts dc for 600 volt rated cable. The test duration shall be one minute. Insulation resistance must be greater than 100 mega-ohm for 600 volt and 25 mega-ohm for 300 volt rated cables per NETA Acceptance Testing Standard. Verify uniform resistance of parallel conductors.

C. MI cable shall have the insulation resistance of each cable tested with a 500-volt dc megohmeter prior to energizing the cables. Tabulate resistance values and submit to Architect/Engineer for acceptance.

D. Inspect wire and cable for physical damage and proper connection.

E. Torque test conductor connections and terminations to manufacturer's recommended values.

F. Perform continuity test on all power and equipment branch circuit conductors. Verify proper phasing connections.

G. Provide documentation of the manufacturer's recommended lug torque value for copper conductors, the date the lugs were torqued, and installed torque readings. Documentation indicating that the torque wrench has been calibrated not more than 30 days prior to tightening of lugs shall be provided.

H. Protection of wire and cable from foreign materials:

1. It is the Contractor's responsibility to provide adequate physical protection to prevent foreign material application or contact with any wire or cable type. Foreign material is defined as any material that would negatively impact the validity of the manufacturer's performance warranty. This includes, but is not limited to, overspray of paint (accidental or otherwise), drywall compound, or any other surface chemical, liquid, or compound that could come in contact with the cable, cable jacket, or cable termination components.

I. Overspray of paint on any wire or cable will not be accepted. It shall be the Contractor's responsibility to replace any component containing overspray, in its entirety, at no additional cost to the project. Cleaning of the cables with harsh chemicals is not allowed.

END OF SECTION 26 05 13

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SECTION 26 05 15 - MEDIUM-VOLTAGE CABLE AND ACCESSORIES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Medium voltage power cable

B. Cable terminations

C. Medium voltage cable accessories

D. Medium voltage cable splices

E. Medium voltage testing

1.2 QUALITY ASSURANCE

A. Manufacturer: Company specializing in medium voltage cable and accessories with minimum five (5) years documented experience.

B. Installer: The installing company shall employ personnel with a minimum of five (5) years documented experience in medium voltage cable installation. Resumes shall be submitted documenting the experience of all personnel pulling, splicing, terminating and testing the medium voltage cable.

C. Installer Certification: The installing company shall submit manufacturer's training certificates for the installing personnel for the splices and terminations being installed.

1.3 REFERENCES

A. AEIC CS8 (Association of Edison Illuminating Companies) - Specification for Extruded Dielectric Shielded Power Cables Rated 5 Through 46 KV

B. ANSI/IEEE C2 - National Electrical Safety Code

C. ICEA S-93-639 (Insulated Cable Engineers Association) / NEMA WC74 - 5-46 kV Shielded Power Cable for Use in the Transmission and Distribution of Electric Energy

D. ICEA S-94-649 - Standard for Concentric Neutral Cables Rated 5 Through 46 KV

E. ICEA S-97-682 - Standard for Utility Shielded Power Cables Rated 5 Through 46 KV

F. IEEE 48 - Standard for Test Procedures and Requirements Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV

G. IEEE 386 - Standard for Separable Insulated Connector Systems for Power Distribution Systems Above 600V

H. IEEE 404 - Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2.5 kV to 500 kV

I. International Electrical Testing Association Ó Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems (refer to the medium voltage cable DC testing requirements)

J. NFPA 70 - National Electrical Code (NEC)

K. UL 1072 - Standard for Medium-Voltage Power Cables

1.4 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of Section 26 05 00.

B. Store and protect products under provisions of Section 26 05 00.

C. Accept cable and accessories on site in manufacturer's packages and inspect for damage.

D. Protect cable and accessories from weather by covering with opaque plastic or canvas; provide ventilation to prevent condensation.

1.5 PROJECT RECORD DOCUMENTS

A. Submit record documents under provisions of Section 26 05 00.

B. Accurately record exact sizes and locations of cables.

1.6 REGULATORY REQUIREMENTS

A. Conform to ANSI/IEEE C2 and the Electrical Code.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Cable product supplied shall be stated by its manufacturer to be suitable for the application for which it will be installed and used, as indicated on project drawings. This includes, but is not limited to, the following applications as permitted by the National Electric Code.

1. Use indoors and/or outdoors.
2. Installation in wet and/or dry locations.
3. Use in conduits and duct banks. Where installed in conduits or underground ducts, the cable manufacturer's product supplied shall be suitable for the conduit sizes specified on the project drawings. Where a manufacturer's cable size is recommended by a given manufacturer to be installed in a larger conduit or underground duct and other acceptable manufacturers' cables are available and the other acceptable manufacturers allow installation of their cables within the drawing conduit sizes and underground duct sizes, cables that work with the conduit sizes and underground duct sizes shown on project drawings shall be supplied.
4. Direct buried installations of cable.
5. Installations in cable trays.
6. Messenger-supported aerial installations in industrial facilities.

B. Manufacturers:

1. The Okonite Company
2. Southwire
3. Prysmian (USA)
4. General Cable
5. The Kerite Company
6. Aetna Insulated Wire

2.2 MEDIUM VOLTAGE POWER CABLE

A. Cable: Insulated, shielded cable rated 15 KV.

B. Electrical Code medium voltage, solid dielectric "Type Letter" shall be MV-105.

C. "Single" or "multi-conductor" cables shall be supplied as indicated on project drawings. Multi-conductor cables shall include full size ground conductors.

D. Conductors shall be copper compact stranded or compressed stranded.. Insulation: Ethylene-propylene rubber (EPR), 133% insulation level. 5 KV rated cable shall have a minimum of 115 mils of insulation for 100 percent insulated cable and a minimum of 140 mils for 133 percent insulated cable. 15 KV rated cable shall have a minimum of 175 mils of insulation for 100 percent insulated cable and a minimum of 220 mils for 133 percent insulated cable.

E. The cable shall have a semi-conducting shield layer over the insulation. The cable shall have a helically applied copper tape metallic shield over previously described layers. The tape shield shall be a minimum of 5 mils thick with a 25 percent overlap.

F. The cable shall have an overall outer moisture and sunlight resistant PVC jacket.

2.3 MANUFACTURERS - CABLE TERMINATIONS AND CABLE SPLICES

A. 3M Company

B. Tyco Electronics (TE Connectivity, Raychem)

C. Elastimold / Thomas & Betts

D. Cooper

E. Prysmian Group

2.4 CABLE TERMINATIONS

A. Medium voltage cable termination types shall be provided as specified on the project drawings and listed in this specification. If no specific type of termination is specified on the drawings, a cable termination type suitable for the equipment or device to which the medium voltage cable is being terminated may be selected from the types described in this specification, given the suitable type is acceptable per the equipment or device manufacturer to which the cable is being terminated. The supplied termination shall be rated for the indoor or outdoor location in which it is being installed and applied. The supplied termination shall also be rated by its manufacturer for the exact type and size of cable to which the termination shall be applied.

B. Cold Shrink Terminations: Termination kits shall meet the requirements of IEEE Standard 48 for Class 1 terminations. Termination shall be installed per the manufacturer's instructions by certified installers who have received authorized training from the manufacturer. Terminations installed on type MC armored cable shall include rejacketing materials to cover any exposed cable shield from the point where the outer MC armor sheath terminates to where the medium voltage termination kit is applied.

C. Heat Shrink Terminations: Termination kits shall meet the requirements of IEEE Standard 48 for Class 1 terminations. Termination shall be installed per the manufacturer's instructions by installers who have received certified training from the manufacturer. Terminations installed on type MC armored cable shall include rejacketing materials over the cable shields from the point where the outer armor terminates to where the medium voltage termination kit is applied. 200 Amp Loadbreak Cable Connectors: IEEE 386 type termination. Cable termination loadbreak elbow connectors, one per each single conductor phase cable. Connectors rated at 200 amps and, as a minimum, rated for the voltage class of the cable and equipment/devices to which the cable is connected. 15 KV rated terminations may be shown and required for 5KV equipment applications. 25 KV rated terminations may be shown and required for 15 KV equipment applications. The loadbreak elbow shall be installed per the manufacturer's instructions. The loadbreak elbow shall work with a corresponding 200-amp loadbreak, IEEE 386 type bushing insert that has been factory supplied and installed. The equipment bushing inserts shall be provided as part of the cable terminations and field installed on the equipment/device if not factory furnished. 600 Amp Deadbreak Cable Connectors: IEEE 386 type termination. Cable termination deadbreak connector, one per each single conductor phase cable. Connectors rated at 600 amps and rated for the voltage class of the cable and equipment/devices to which the cable is connected. THIS CONNECTOR IS NOT INTENDED TO BE DISCONNECTED WHILE ENERGIZED. Connector shall be installed per the manufacturer's instructions. The deadbreak connector shall work with a corresponding 600-amp, IEEE 386 type deadbreak equipment bushing that has been factory supplied and installed. The IEEE 386 type, 600-amp equipment bushings shall be provided as part of the cable terminations and field installed on the equipment/device if not factory furnished.

2.5 CABLE ACCESSORIES

A. Park Stands: Insulated with cap, rated 15 KV for IEEE 386 type of cable terminations. Supply if shown on project drawings.

B. Lightning Surge Arresters: For use with IEEE 386 cable terminations. Elbow construction, rated 15 KV, MCOV rating of 15.3 KV, duty cycle rating of 18 KV.

2.6 CABLE SPLICES

1. Modular splicing systems, fully shielded, with 600-amp continuous current rated separable, bolted connectors that meet the requirements of ANSI/IEEE Standard 386. The splicing kits shall be suitable for use on 5, 8, 15, and 25 kV shielded power cables. Kits supplied shall have cable adapters to match the type of cable, such as tape-shielded, wire shielded, or cable with a jacketed concentric neutral. A capacitive test point on the connector insulating plug shall provide a safe means of testing the circuit without disturbing the bolted connection. The completed installation shall be fully shielded to provide a complete dead front connection that is suitable for operation submerged or in direct buried locations. The splice system shall be able to expand to connect two, three, or four conductors. Provide modular splices with the following voltage ratings and characteristics in accordance with ANSI/IEEE Standard 386 for use with 25 kV or less rated cables. Cables over 25 kV shall use splice kits rated by the splice kit manufacturer for the voltage and current ratings of the cable, with detailed voltage rating parameters supplied by the splice kit manufacturer:

   a. Rated a minimum of 25 kV when used for 5, 8, 15, and 25 kV cable.
   b. 15.2 kV maximum phase-to-ground rating on 25 kV maximum rated splices.
   c. 40 kV AC, 60-hertz, one minute withstand rating.
   d. 78 kV DC 15 minute withstand rating.
   e. 125 kV BIL and full wave crest rating.
   f. 19 kV minimum corona voltage level.

2. Provide modular splices with the following current ratings and characteristics in accordance with ANSI/IEEE Standard 386 for use with 25 kV or less rated cables:

   a. The modular splices shall be rated for 600-amps continuous current.
   b. The splices shall have a 1000-amp RMS, 24 hour overload rating.

c. The splices shall have a 40 kA RMS symmetrical withstand rating for 0.20 seconds (12 cycles) and a 27 kA RMS symmetrical rating for 4 seconds (240 cycles).

3. Use cable adapters ordered as part of the modular splice kits that are intended by the splice kit manufacturer to be used with the cables being connected to the splice connector.
4. Install the modular splices in accordance with the manufacturer's instructions.
5. The modular splices shall not be high potential cable tested at voltages above the modular splice manufacturer's specifications for testing.

B. Inline splice kits for splicing two conductors of the same phase together per each splice connection.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that conduit, duct banks, cable trays, trenches, or other raceways, as may be applicable to the project, are ready for cable installation.

B. Beginning of installation means installer accepts existing conditions.

3.2 PREPARATION

A. Thoroughly swab conduits to remove foreign material before pulling cables.

3.3 INSTALLATION

A. Install cable and terminations in accordance with manufacturer's instructions and to ANSI/IEEE C2.

B. Ground cable shield at each termination and splice with a shield adapter kit consisting of braided ground lead and a shrink tube cover.

C. Pull cables using suitable water-based lubricants and cable pulling equipment. Do not exceed cable pulling tensions and bending radius recommended by manufacturer.

D. Install cable in manholes along those walls providing the longest route and most spare cable lengths. Arrange cable to avoid interferences with duct entrances into manhole.

E. Avoid abrasion and other damage to cables during installation.

F. Fireproof cables in manholes using fireproofing tape in half-lapped wrapping extended one inch into ducts.

G. Loop cables around manhole where terminations are not required.

H. Medium voltage cables shall be continuous between junction boxes, pull boxes, manholes, or equipment terminal cabinets. No splices will be permitted in medium voltage cables except at junction boxes, pull boxes, manholes, or equipment terminal cabinets.

I. Provide park stands in equipment adjacent to each load break cable termination if not supplied with the equipment.

J. Install lightning arresters where shown on the one-line diagram.

3.4 FIELD QUALITY CONTROL - VERY LOW FREQUENCY (VLF) TESTING

A. Field inspection and testing shall be performed under provisions of Section 26 05 00.

B. Inspect exposed cable sections for physical damage. Verify that cable is connected according to drawings and that shield grounding, cable support, and terminations are properly installed.

C. Contractor shall inform Architect/Engineer of testing schedule to be performed one week prior to commencing testing should they want to witness testing.

D. Cable Testing: The Contractor shall verify this test procedure with the cable manufacturer, the cable termination manufacturers, and the cable splice manufacturers to receive their approval for conducting the following tests. The Contractor shall ensure that the maximum test voltage does not exceed the limits for terminations or splices specified in ANSI/IEEE48, IEEE 386, or the manufacturer's specifications. The medium voltage cable testing shall be performed in accordance with the IEEE Standard 400.2-2013 covering VLF cable testing and the International Electrical Testing Association (NETA) Acceptance Testing Specifications for Electrical Power Distribution Equipment and Systems, specifically the sections relevant to VLF medium voltage cable testing, plus the information contained in this specification. Performance of the test by the Contractor shall constitute acceptance has been received and approved.

1. Perform VLF "acceptance" withstand testing and VLF-TD "tangent delta" power dissipation factor tests on each new medium voltage shielded cable segment after all splice connectors and cable termination stress cones have been completed, but with the cables disconnected from circuit breakers, switches, junction boxes, and equipment. Apply test potential between each conductor and its grounded insulation shield, with the other two circuit conductors and shields grounded. On armored cable, ground the armor and interstice conductors during tests on interlocked armor cable.
2. The VLF "acceptance test voltage" shall be per IEEE Standard 400.2-2013 or the latest version, Table-3, relative to testing with a sinusoidal wave form at 0.1 hertz. Acceptance testing time shall be for 60 minutes on new cable, but if the cable test is stable for at least 15 minutes and no failures occur, the withstand test may be for just 30 minutes. Check cable, termination kits, and splice kit manufacturer's recommended test voltages and never exceed cable manufacturer's recommended test voltages:

    a. VLF withstanding test voltages for sinusoidal waveforms; refer to IEEE 400.2.

Cable System Rating KV	Installation (phase to ground)		Acceptance (phase to ground)		Maintenance (phase to ground)	
	KV (rms)	KV peak	KV (rms)	KV peak	KV (rms)	KV peak
5	9	13	10	14	7	10
8	11	16	13	18	10	14
15	19	27	21	30	16	22

    b. VLF-TD, "tangent delta", dissipation factor" testing shall be done in accordance with IEEE Standard 400.2-2013, Section 5.4. The tangent delta shall be measured at 0.5U0, U0, and 1.5U0, where "U0" is the normal phase-to-ground operating voltage. The VLF-DTD, "differential tangent delta" shall be calculated, and the VLF-TDTS, "tangent delta temporal stability" shall also be calculated. All readings shall be recorded for the cable under test at the test voltages. Relative to new cable, per IEEE Standard 400.2-2013, Section 5.4.5, the diagnostic test results for the new cable should not be absolutely compared to the standard aged figures of merit for test results, but the cable data will be available for future comparison on any subsequent tests. Relative comparisons between phases should be able to be made. Significantly high dissipation factors associated with a phase in comparison to other phases could be cause for concern.

3. VLF Testing:

    a. VLF testing shall be done with calibrated VLF cable test equipment.
    b. The testing shall be done in full accordance with the test equipment manufacturer's instructions for proper and safe use of the equipment.

c. Test results shall be recorded for each cable / conductor tested, with the date and time of the test as part of the recorded information.

d. The test results shall be summarized in a test report, of which an electronic copy shall be submitted to Architect/Engineer. The report shall indicate whether the test result is satisfactory and the conductor should be accepted for service.

e. The Contractor shall notify the Architect/Engineer upon failed test results and not acceptable for service. The failed cable shall be replaced under warranty at no additional cost to the Owner.

4. Cables shall pass the specified withstand tests without breakdown. When a subsequent test is required, it shall similarly withstand the test voltage specified by Architect/Engineer. Do not exceed the published test values recommended by the cable manufacturer, termination kit manufacturer, or cable splice kit manufacturer. The Electrical Contractor is responsible for verifying and documenting the written test value limits from the various component manufacturers.

5. Obtain Architect/Engineer acceptance on cable test report(s) per submittal review process prior to energizing the cables.

E. Test Report Format: An example VLF test report has been included as an example at the end of this section. The Contractor may submit a similar standard form that includes the same information.

TABLE OF MAXIMUM DC TEST VOLTAGES OF NEW CABLE					
Cable test voltages may need to be less due to cable termination device limitations or lower cable manufacturer specified limits.					
		Nominal Insulation Thickness mils		Maximum DC Field Test Voltages, KV During/After Installation	
Rated Voltage Phase-to Phase KV	Conductor Size AWG or KCMIL	100% Insulation Level	133% Insulation Level	100% Insulation Level	133% Insulation Level
5	8 Ó 1000	90	115	28	36
5	Above 1000	140	140	28	36
8	6 - 1000	115	140	36	44
8	Above 1000	175	175	36	44
15	2 - 1000	175	220	56	64
15	Above 1000	220	220	56	64

END OF SECTION 26 05 15

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SECTION 26 05 17 - ELECTRIC HEAT TRACE AND SNOW MELT

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Heat tracing cables

B. Snow and ice melting cables

C. Controls

1.2 REFERENCES

A. NFPA 70 - National Electrical Code (NEC)

B. ASTM 2633 - Standard Test Method for Thermoplastic Insulations

C. ASTM B193 - Standard Test Method for Resistivity of Electrical Conductor Materials

D. UL 746B - Polymeric Materials - Long Term Property Evaluations

E. NFPA 13 - Standard for Installation of Sprinkler Systems

1.3 SUBMITTALS

A. Submit shop drawings under provisions of Section 26 05 00.

B. Product Data: For each type of product indicated.

1. Field Test Reports: Submit written test reports to include 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.

C. Submit manufacturer's instructions under provisions of Section 26 05 00.

1.4 COORDINATION

A. Coordinate layout and installation of electrical heating cables and system components with General Contractor.

B. Coordinate installation of snow-melting cable with installation of concrete framework and concrete placement.

1.5 WARRANTY

A. Provide a ten (10) year warranty under provisions of Section 26 05 00.

PART 2 - PRODUCTS

2.1 HEAT-TRACING CABLE

A. Self-Regulating Heating Cable:

1. Cable shall be capable of crossing over itself without overheating.
2. Provide power end seals and splices as required.

   a. Each circuit shall be protected by a 30-mA ground-fault protection device. Provide number of breakers based on manufacturer's maximum length for startup at 0°F. Identify breaker in panel directory as "HEAT TAPE".

3. Heat tape shall be meggered prior to insulating piping.
4. HT-1; Suitable for freeze protection of above grade insulated metal or plastic piping, valves, and equipment to maintain fluid temperature above 40°F. 8 watts per foot @ 50°F, 277°V.

   a. Manufacturers:

      1) Ray-Chem XL1
      2) Chromalox SRL
      3) Thermon BSX
      4) Delta-Therm IN

5. HT-1: Suitable for freeze protection of underground insulated metal or plastic piping to maintain fluid temperature above 40°F. 8 watts per foot, 277 V.

   a. Manufacturers:

      1) Ray-Chem XL
      2) Chromalox SRL
      3) Thermon BSX
      4) Delta-Therm IN

2.2 SNOW AND ICE MELTING CABLES

A. Self-Regulating Cable:

1. Heat tape shall be meggered prior to paving installation.
2. Provide power connection, end seal, splices and expansion joint kits as required.
3. Each circuit shall be protected by a 30-mA ground-fault protection device. Provide number of breakers based on manufacturer's maximum length for startup at 0°F. Identify breaker in panel directory as "SNOW MELT".
4. HT-1; Suitable for installation in concrete asphalt pavement to melt snow and ice. 55 watts per square foot, 277 V. Cables must be secured to reinforcing steel or mesh. Cable spacing shall not exceed 12". Cables must be installed 1-1/2" to 2" below finished surface.

   a. Manufacturers:

      1) Ray-Chem EM2-XR
      2) Chromalox
      3) Thermon
      4) Delta-Therm

5. HT-1; Suitable for use on roof eaves, downspouts, and gutters for snow and ice melting. 12 watts per foot in ice or snow and 5 watts per foot in air, 277 V. Cables shall be attached with manufacturer approved clips for all roof surfaces, valleys, and downspout hangers.

a. Manufacturers:

1) Ray-Chem GM-1XT or GM-2XT
2) Chromalox
3) Thermon
4) Delta-Therm

2.3 CONTROLS

A. SMP-1; Snow Melt Control Panel with Remote Snow Sensors:

1. NEMA 3R 120-volt, adjustable hold-on timer, automatic/off/manual switch. Provide with remote Class II aerial solid state precipitation and temperature sensor, and a pavement-mounted snow sensor. Two (10mA) override inputs and four (10mA) contacts to support remote monitoring and control.
2. Manufacturers:

a. Environmental Technology
b. Inc. APS-3C
c. Ray-Chem
d. Chromalox APS-3C
e. Delta-Therm

B. SMP-1; Snow Melt Distribution and Control Panel with Remote Snow Sensors:

1. Branch circuit and control panel. NEMA 3R/4 enclosure. 480 volt 3 phase 100-amp main breaker circuit breaker panel with 1 pole 30mA ground fault protection branch breakers. Snow melt control panel with adjustable hold-on timer, automatic/off/manual switch. Provide with remote Class II aerial solid state precipitation and temperature sensor and a pavement-mounted snow sensor. Two (10mA) override inputs and four (10mA) contacts to support remote monitoring and control.
2. Manufacturers:

a. Pentair SMPG1

C. SMS-1; Pavement mounted Deicing/Snow Controller:

1. Control sensor that senses precipitation and temperature to energize contactor circuit under conditions indicating snow. 24 volt. Provided remote 30-amp contactor with 24-volt control transformer for snow melt control.
2. Manufacturer:

a. Environmental Technology, Inc. HSC-4 & SC-40C contactor

D. SMP-1**;** Freeze Protection for Sprinkler Protection Systems with Sensors:

1. Description, UL Listed for Sprinkler System Freeze Protection
2. Supervisory alarms for fire alarm system monitoring:

a. Ground Fault
b. Low Sprinkler System Temperature
c. Hight Sprinkler System Temperature
d. Temperature Sensor Failure
e. Primary Controller Failure
f. Loss of Continuity
g. Loss of Incoming Supply Voltage

3. Manufacturer:

   a. Chromalox ITC Series

E. Ambient Thermostat:

1. Remote bulb unit with adjustable temperature range from 15°F to 150°F snap action, open-on-rise, single-pole double throw switch with 22A 125/250/480VAC ratings. Provide one pipe thermostat for each circuit of heat trace.
2. Manufacturer:

   a. Pentair AMC-1A

F. Pipe Thermostat:

1. Ambient sensing unit with adjustable temperature range from 15°F to 150°F snap action; open-on-rise, single-pole double throw switch with 22A 125/250/480VAC ratings; and remote bulb for directly sensing pipe-wall temperature. Provide one pipe thermostat for each circuit of heat trace.
2. Manufacturer:

   a. Pentair AMC-1A

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine surface and substrates to receive heating cables for compliance with requirements for installation, tolerances, and other conditions affecting performance.

1. Ensure surfaces and pipes in contact with electrical heating cables are free of burrs and sharp protrusions.
2. Ensure pipe testing is complete.
3. Ensure surfaces and substrates are level and plumb.

B. Test cables for electrical continuity before installing.

C. Test cables for insulation resistance before installing.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

E. Verify field measurements are as shown on the Drawings.

3.2 INSTALLATION

A. Install products in accordance with manufacturer's instructions.

B. The heating cable shall be protected from where it leaves the pavement to the junction box by installing the cable in rigid metal conduit. Use one conduit for each heating cable.

C. Avoid crossing expansion, construction, or control joints with heating cables. Provide sufficient slack conductor in expansion loop.

D. Do not energize cables embedded in concrete, asphalt, or plaster until those assemblies are cured, except for brief testing.

E. Install cables after applying bituminous binder course to lower base. Ensure that second labeling bituminous binder is applied to cables before pouring finish topping.

F. Provide labeling in paving where snow melt cables are present. A metal plate or stamp used prior to concrete setting must contain the name of the snow melt company, the word "CAUTION", the phrase "EMBEDDED SNOW MELTING SYSTEM", and the date the system was installed. The labeling of the system must be able to handle the outdoor environment without degrading.

G. Provide labeling to outside of the pipe thermal insulation weather barrier to indicate the presence of electric heating tracing. Labeling should contain the name of the heat trace company, the word "CAUTION" and the phrase 'ELECTRIC HEAT TRACE". Labels should be placed every ten feet of pipe alternating on either side of the pipe.

3.3 CONNECTIONS

A. Cable splices and repairs shall be made using a splice kit provided by the manufacturer and specifically designed for that purpose.

B. Power connection and end seal junction box shall be mounted above grade. The junction box shall be installed in such a way so that water cannot enter it.

3.4 FIELD QUALITY CONTROL

A. Inspect cable for physical damage before installation.

B. Test cables for electrical continuity before energizing.

C. Test cables for insulation resistance before energizing. Remove cables if measured resistance is less than 10 megohms to ground.

D. Repeat test for continuity and insulation resistance after applying paving or thermal insulation.

END OF SECTION 26 05 17

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SECTION 26 05 26 - GROUNDING AND BONDING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Equipment grounding system

B. Bonding system

C. Grounding electrode system

1.2 QUALITY ASSURANCE

A. Testing Agency Qualifications: Testing agency as defined by OSHA in 29 CFR 1910.7 or a member company of the International Electrical Testing Association and that is acceptable to authorities having jurisdiction.

B. Testing Agency's Field Supervisor: Person currently certified by the International Electrical Testing Association to supervise on-site testing specified in Part 3.

C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in Electrical Code, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

D. Comply with UL 467 Grounding and Bonding Equipment.

E. Comply with Electrical Code; for overhead-line construction and medium-voltage underground construction, comply with IEEE/ANSI C2 National Electrical Safety Code (NESC).

1.3 REFERENCES

A. NFPA 70 - National Electrical Code (NEC)

1.4 SUMMARY

A. This section includes grounding of electrical systems and equipment. Grounding requirements specified in this Section may be supplemented by special requirements of systems described in other Sections.

PART 2 - PRODUCTS

2.1 GROUNDING CONDUCTORS

A. For insulated conductors, comply with Division 26 Section 26 05 13 "Wire and Cable".

B. Material: Copper.

C. Equipment Grounding Conductors: Insulated. Refer to Section 26 05 53 for insulation color.

D. Grounding Electrode Conductors: Stranded cable.

E. Copper Bonding Conductors: As follows:

1. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG copper conductor, 1/4 inch in diameter.
2. Bonding Conductor: No. 4 or No. 6 AWG, stranded copper conductor.
3. Bonding Jumper: Bare copper tape, braided bare copper conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
4. Tinned Bonding Jumper: Tinned-copper tape, braided copper conductors, terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.

F. GB; Grounding Bar:

1. Bare, annealed copper bars of rectangular cross section, with insulators. 1/4" x 2", length of technology or applicable room.

G. IBT; Intersystem Bonding Termination:

1. Copper bar, 1/4" x 2" x 24". Provide with wall mounting brackets, insulators and pre-tapped holes.
2. Manufacturers:

a. Harger GBI Series.
b. Erico EGB Series.

2.2 CONNECTOR PRODUCTS

A. Comply with UL 467; listed for use for specific types, sizes, and combinations of conductors and connected items.

B. Connectors: Exothermic-welded type, in kit form, and selected per manufacturer's written instructions.

C. Bolted Connectors: Bolted-pressure-type connectors.

D. Substation connectors shall comply with IEEE 837 listed for use for specific types, sizes, and combinations of conductors and connected items.

2.3 GROUNDING ELECTRODES

A. Ground Rods Copper-clad steel.

B. Ground Rods: Sectional type; copper-clad steel.

1. Size: 3/4" in diameter by 120 inches per section.

C. Chemical Electrodes: Copper tube, straight or L-shaped, filled with nonhazardous chemical salts, terminated with a 4/0 bare conductor. Provide backfill material recommended by manufacturer.

D. Test Wells: Provide handholes as shown on drawings or as specified in Division 2 Section "Underground Ducts and Utility Structures."

E. Concrete-Encased Grounding Electrode (Ufer): Fabricate according to Electrical Code, using a minimum of 20 feet of bare copper conductor not smaller than No. 4 AWG or 20 feet of 1/2"steel reinforcing bar.

PART 3 - EXECUTION

3.1 CONNECTIONS

A. General: Make connections so galvanic action or electrolysis possibility is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.

1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer to order of galvanic series.
2. Make connections with clean, bare metal at points of contact.
3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
4. Make aluminum-to-galvanized steel connections with tin-plated copper jumpers and mechanical clamps.
5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

B. Exothermic-Welded Connections: Comply with manufacturer's written instructions. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.

C. Compression-Type Connections: Use hydraulic compression tools to provide correct circumferential pressure for compression connectors. Use tools and dies recommended by connector manufacturer. Provide embossing die code or other standard method to make a visible indication that a connector has been adequately compressed on grounding conductor.

D. Equipment Grounding Conductor Terminations: For No. 8 AWG and larger, use pressure-type grounding lugs. No. 10 AWG and smaller grounding conductors may be terminated with winged pressure-type connectors.

E. Noncontact Metal Raceway Terminations: If metallic raceways terminate at metal housings without mechanical and electrical connection to housing, terminate each conduit with a grounding bushing. Connect grounding bushings with a bare grounding conductor to grounding bus or terminal in housing. Bond electrically non-continuous conduits at entrances and exits with grounding bushings and bare grounding conductors, unless otherwise indicated.

F. Structural Steel Connection: Exothermic-welded connections to structural steel. Coordinate with structure to provide physical protection.

G. Underground Connections: Exothermic-welded connections. Use for underground connections, except those at test wells.

H. Connections at Test Wells: Use compression-type connectors on conductors and make two bolted- and clamped-type connections between conductors and ground rods.

I. Connections at back boxes, junction boxes, pull boxes, and equipment terminations: The equipment grounding conductor(s) associated with all circuits in the box shall be connected together and to the box using a suitable grounding screw. The removal of the respective receptacle, luminaire, or other device served by the box shall not interrupt the grounding continuity. The connection to the non-metallic boxes shall be made to any metallic fitting or device requiring grounding.

J. Tighten screws and bolts for grounding and bonding 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.

K. Moisture Protection: If insulated grounding conductors are connected to ground rods or grounding buses, insulate entire area of connection and seal against moisture penetration of insulation and cable.

3.2 INSTALLATION

A. Use only copper conductors for both insulated and bare grounding conductors in direct contact with earth, concrete, masonry, crushed stone, and similar materials.

B. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage. Each grounding conductor that passes through a below grade wall must be provided with a waterstop.

C. Grounding electrode conductor (GEC) shall be protected from physical damage by rigid polyvinyl chloride conduit (PVC) in exposed locations.

D. Bonding Straps and Jumpers: Install so vibration by equipment mounted on vibration isolation hangers and supports is not transmitted to rigidly mounted equipment. Use exothermic-welded connectors for outdoor locations, unless a disconnect-type connection is required; then use a bolted clamp. Bond straps directly to the basic structure, taking care not to penetrate any adjacent parts. Install straps only in locations accessible for maintenance.

E. In raceways, use insulated equipment grounding conductors.

3.3 EQUIPMENT GROUNDING SYSTEM

A. Comply with Electrical Code, for types, sizes, and quantities of equipment grounding conductors, unless specific types, larger sizes, or more conductors than required by Electrical Code are indicated.

B. Install equipment grounding conductors in all feeders and circuits. Terminate each end on a grounding lug or bus.

C. Install insulated equipment grounding conductor with circuit conductors for the following items, in addition to those required by Electrical Code:

1. Lighting and receptacle circuits. Terminate each end on a grounding lug or bus.
2. Single-phase and three-phase motor and appliance branch circuits.
3. Flexible raceway runs, including FMC and LFMC.

D. Computer Outlet Circuits: Install insulated equipment grounding conductor in branch-circuit runs from computer-area power panels or power-distribution units.

E. Nonmetallic Raceways: Install an equipment grounding conductor in nonmetallic raceways unless they are designated for telephone or data cables.

3.4 BONDING SYSTEM

A. At building expansion joints, provide flexible bonding jumpers to connect to columns or beams on each side of the expansion joint.

B. Isolated Equipment Enclosure: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate equipment bonding conductor.

C. Exterior Metallic Pull and Junction Box Covers, Metallic Hand Rails: Bond to grounding system using flexible grounding conductors.

D. Equipment Circuits: Install a bonding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, dampers, and heaters. Bond conductor to each unit and to air duct. Bond interior metal piping systems and metal air ducts to equipment grounding conductors of associated pumps, fans, blowers, electric heaters, and air cleaners. Use braided-type bonding straps or copper conductor sized equal to the equipment grounding conductor.

E. Bond metal ducts of dust collectors, particulate conveying, fume hoods, and other hazardous materials to the equipment grounding conductors of associated pumps, fans, or blowers. Use braided-type bonding straps. Provide braided bare copper bonding conductor in nonmetallic dust collector ductwork to each equipment inlet location, and bond to equipment.

F. Water Heater, Heat-Tracing, Metal Well Casing, and Heating Cables: Install a separate equipment grounding conductor to each electric water heater, heat-tracing, and anti-frost heating cable. Bond conductor to heater units, piping, well casing, connected equipment, and components.

G. Connect bonding conductors to metal water pipe using a suitable ground clamp. Make connections to flanged piping at street side of flange. Provide bonding jumper around water meter.

H. Signal and Communication Systems: For telephone, alarm, voice and data, and other communication systems, provide No. 6 AWG minimum insulated bonding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location. Leave 10 feet of slack conductor at terminal board.

I. Telecom Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-2-by-12-inch grounding bar.

J. Terminal Cabinets: Terminate bonding conductor on cabinet grounding terminal.

K. Remote control, signaling, and fire alarm circuits shall be bonded in accordance with the most recent version of the National Electric Code.

3.5 GROUNDING ELECTRODE SYSTEM

A. Supplementary Grounding Electrode: Use driven ground rod on exterior of building.

B. Provide bonding at metering equipment and pad mounted transformer.

C. Ground Rods: Install at least two rods spaced at least 20 feet from each other and located at least the same distance from other grounding electrodes.

1. Drive ground rods until tops are 12 inches below finished floor or final grade, unless otherwise indicated.
2. Interconnect ground rods with grounding electrode conductors. Use exothermic welds, except at test wells and as otherwise indicated. Make connections without exposing steel or damaging copper coating.

D. Metal Water Service Pipe: Provide insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes by grounding clamp connectors. Where a dielectric main water fitting is installed, connect grounding conductor to street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.

E. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters, filtering devices, and similar equipment. Connect to pipe with grounding clamp connectors.

F. Natural Gas Service Piping: Bond to natural gas main service with grounding clamp connectors. Bonding conductor shall be connected to the main service ground bar. Provide grounding jumpers around all breaks in metallic continuity.

G. Natural Gas Equipment Piping: Bond each aboveground portion of natural gas metallic piping system at each equipment location with grounding clamp connectors. Bonding shall be performed after any flexible attachment nearest the equipment. The equipment grounding conductors may serve as the bonding means.

H. Install one test well for each service at the ground rod electrically closest to the service entrance. Set top of well flush with finished grade or floor.

I. Concrete-Encased Grounding Electrode (Ufer): Install concrete-encased grounding electrode encased in at least 2 inches of concrete horizontally within the foundation that is in contact with the earth. If concrete foundation is less than 20 feet long, coil excess conductor within the base of the foundation. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building grounding grid or to a grounding electrode external to concrete.

3.6 FIELD QUALITY CONTROL

A. Inspect grounding and bonding system conductors and connections for tightness and proper installation.

1. Measure ground resistance from system neutral connection at service entrance to convenient ground reference points using suitable ground testing equipment. Resistance shall not exceed 5 ohms.
2. Testing: Perform the following field quality-control testing:

a. After installing grounding system but before permanent electrical circuitry has been energized, test for compliance with requirements.
b. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, and at ground test wells. Measure ground resistance not less than two full days after the last trace of precipitation, and without the soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance. Perform tests, by the fall-of-potential method according to IEEE 81.
c. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect/Engineer promptly and include recommendations to reduce ground resistance.

3.7 GRADING AND PLANTING

A. Restore surface features, including vegetation, at areas disturbed by Work of this Section. Reestablish original grades, unless otherwise indicated. If sod has been removed, replace it as soon as possible after backfilling is completed. Restore areas disturbed by trenching, storing of dirt, cable laying, and other activities to their original condition. Include application of topsoil, fertilizer, lime, seed, sod, sprig, and mulch. Comply with Division 2. Maintain restored surfaces. Restore disturbed paving.

END OF SECTION 26 05 26

SECTION 26 05 27 - SUPPORTING DEVICES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Conduit and Equipment Supports

B. Fastening Hardware

C. Concrete Housekeeping Pads

1.2 QUALITY ASSURANCE

A. Support systems shall be adequate for weight of equipment and conduit, including wiring, which they carry.

1.3 COORDINATION

A. Coordinate size, shape and location of concrete pads with section on Cast-in-Place Concrete or Concrete Topping.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Allied Support Systems

B. Cooper B-Line

C. Erico, Inc.

D. Hilti

E. Power Fasteners

F. Orbit Industries

2.2 MATERIAL

A. Support Channel: Hot-dip galvanized for wet/damp locations; painted steel for interior/dry locations. All field cut ends shall be touched up with matching finish to inhibit rusting.

B. Hardware: Corrosion resistant.

C. Anchorage and Structural Attachment Components:

1. Strength: Defined in reports by ICBO Evaluation Service or another agency acceptable to Authorities Having Jurisdiction.

a. Structural Safety Factor: Strength in tension and shear of components used shall be at least two times the maximum seismic forces to which they will be subjected.

2. Through Bolts: Structural type, hex head, high strength. Comply with ASTM A 325.
3. Welding Lugs: Comply with MSS-SP-69, Type 57.
4. Beam clamps for Steel Beams and Joists: Double sided or concentric open web joist hangars. Single-sided type is not acceptable.
5. Bushings for Floor-Mounted Equipment Anchors: Neoprene units designed for seismically rated rigid equipment mountings, and matched to the type and size of anchor bolts and studs used.
6. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for seismically rated rigid equipment mountings, and matched to the type and size of attachment devices used.
7. Concrete Anchors: Fasten to concrete using cast-in or post-installed anchors designed per the requirements of Appendix D of ACI 318-05. Post-installed anchors shall be qualified for use in cracked concrete by ACI-355.2.
8. Masonry Anchors: Fasten to concrete masonry units with expansion anchors or self-tapping masonry screws. For expansion anchors into hollow concrete block, use sleeve-type anchors designed for the specific application. Do not fasten in masonry joints. Do not use powder actuated fasteners, wooden plugs, or plastic inserts.

D. Conduit Sleeves and Lintels:

1. Each Contractor shall provide, to the General Contractor for installation, lintels for all openings required for the Contractor's work in masonry walls and conduit sleeves for floors, unless specifically shown as being by others.
2. Refer to Structural plans and specifications for lintel requirements and sizes.
3. Fabricate all lintels from structural steel shapes or as indicated on the drawings. All lintels and grouped wall openings shall be approved by the Architect or Structural Engineer.
4. Fabricate all sleeves from standard weight black steel pipe. Provide continuous sleeve. Cut or split sleeves are not acceptable. Sleeves through concrete walls may be high density polyethylene pipe penetration sleeve with a water stop collar, suitable for use with Link-Seal mechanical seals. Century-Line Model CS.
5. Sleeves through the floors on exposed risers shall be flush with the ceiling, with planed squared ends extending 1" above the floor in unfinished areas, and flush with the floor in finished areas, to accept spring closing floor plates.
6. Sleeves shall not penetrate structural members without approval from the Structural Engineer.
7. Openings through unexcavated floors and/or foundation walls below the floor shall have a smooth finish with sufficient annular space around material passing through opening so slight settling will not place stress on the material or building structure.
8. Install all sleeves concentric with conduits. Secure sleeves in concrete to wood forms. This Contractor is responsible for sleeves dislodged or moved when pouring concrete.
9. Where conduits rise through concrete floors that are on earthen grade, provide 3/4" resilient expansion joint material (asphalt and cork) wrapped around the pipe, the full depth of concrete, at the point of penetration. Secure to prevent shifting during concrete placement and finishing.
10. Size sleeves large enough to allow expansion and contraction movement.

E. Concrete Housekeeping Pads:

1. Concrete bases for all floor mounted equipment and wall mounted equipment which is surface mounted and extends to within 6" of the finished floor, unless shown otherwise on the drawings, shall be 3-1/2" thick concrete.
2. Bases shall extend 3" on all sides of the equipment (6" larger than factory base).
3. Where the base is less than 12" from a wall, the base shall be carried to the wall to prevent a "dirt-trap".
4. Concrete materials and workmanship required for the Contractor's work shall be provided by the Contractor. Materials and workmanship shall conform to the applicable standards of the Portland Cement Association. Reinforce with 6" x 6", W1.4-W1.4 welded wire fabric. Concrete shall withstand 3,000 pounds compression per square inch at twenty-eight days.

F. Rooftop Support System:

1. Provide pre-fabricated roof supports for all conduit and equipment installed above the roof. Support all conduit and equipment a minimum of 4" above roof.
2. Support system shall be compatible with single ply, bituminous, metal, and spray foam roof systems. The base shall be rounded to prevent damage to the roof, and drainage holes shall prevent ponding of water in the support.
3. All metal components shall be hot dipped galvanized. Mounting hardware shall be stainless steel or hot dipped galvanized. Support shall be UV, corrosion, and freeze/thaw resistant. Support shall include orange paint, reflective safety orange accents, or similar markings for increased visibility.
4. Products:

    a. Anvil International HBS-Base Series
    b. Cooper B-Line Dura-Blok
    c. Erico Caddy Pyramid 50, 150, 300, or 600 (to match load).

G. Truss and Joist Support System: Provided the installation complies with all loading requirements of truss and joist manufacturers, the following practices are acceptable:

1. Loads of 100 lbs. or less may be attached anywhere along the top or bottom chords of trusses or joists with a minimum 3' spacing between loads.
2. Loads greater than 100 lbs. must be hung concentrically and may be hung from top or bottom chord, provided one of the following conditions is met:

    a. The hanger is attached within 6" from a web/chord joint.
    b. Additional L2x2x1/4 web reinforcement is installed per manufacturer's requirements.

3. It is prohibited to cantilever a load using an angle or other structural component that is attached to a truss or joist in such a fashion that a torsional force is applied to that structural member.
4. If conditions cannot be met, coordinate installation with truss or joist manufacturer and contact Architect/Engineer.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Fasten hanger rods, conduit clamps, and outlet and junction boxes to building structure using expansion anchors in concrete and beam clamps on structural steel.

B. Trapeze support installation: Cut hanger rods back at trapeze supports so they do not extend more than 3/4" below bottom face of lowest fastener and blunt any sharp edges.

C. Use toggle bolts or hollow wall fasteners in hollow masonry, plaster, or gypsum board partitions and walls; expansion anchors or preset inserts in solid masonry walls; self-drilling anchors or expansion anchor on concrete surfaces; sheet metal screws in sheet metal studs; and wood screws in wood construction.

D. Do not fasten supports to ceiling systems, piping, ductwork, mechanical equipment, or conduit, unless otherwise noted.

E. Do not use powder-actuated anchors without specific permission.

F. Do not drill structural steel members.

G. Fabricate supports from structural steel or steel channel, rigidly welded or bolted to present a neat appearance. Use hexagon head bolts with spring lock washers under all nuts.

H. In wet locations and on all building floors below exterior earth grade install free-standing electrical equipment on concrete pads.

I. Install cabinets and panelboards with minimum of four anchors. Provide horizontal backing/support framing in stud walls for rigid mounting.

J. Bridge studs top and bottom with channels to support flush-mounted cabinets and panelboards in stud walls.

K. Do not exceed 25 lbs. per hanger and a minimum spacing of 2'-0" on center when attaching to metal roof decking (excludes concrete on metal deck). This 25 lbs. load and 2'-0" spacing include adjacent electrical and mechanical items hanging from deck. If the hanger restrictions cannot be achieved, supplemental framing off steel framing will need to be added.

L. Refer to Section 26 05 33 for special conduit supporting requirements.

3.2 FINISH

A. Prime coat exposed steel hangers and supports. Hangers and supports in crawl spaces, pipe shafts, and above suspended ceiling spaces are not considered exposed.

B. Trim all ends of exposed field fabricated steel hangers, slotted channel and threaded rod to within 1" of support or fastener to eliminate potential injury to personnel unless shown otherwise on the drawings. Smooth ends and install elastomeric insulation with two coats of latex paint if exposed steel is within 6'-6" of finish floor and presents potential injury to personnel.

END OF SECTION 26 05 27

SECTION 26 05 33 - CONDUIT AND BOXES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Rigid metallic conduit and fittings (RMC)

B. Intermediate metallic conduit and fittings (IMC)

C. Electrical metallic tubing and fittings (EMT)

D. Liquidtight flexible metallic conduit and fittings (LFMC)

E. Rigid polyvinyl chloride conduit and fittings (PVC)

F. Wall and ceiling outlet boxes

G. Electrical connection

H. Pull and junction boxes

I. Accessories

1.2 RELATED WORK

A. Section 26 05 53 - Electrical Identification: Refer to electrical identification for color and identification labeling requirements.

1.3 REFERENCES

A. American National Standards Institute (ANSI):

1. ANSI C80.1 - Rigid Steel Conduit, Zinc-Coated
2. ANSI C80.3 - Electrical Metallic Tubing, Zinc-Coated and Fittings
3. ANSI C80.4 - Fittings for Rigid Metal Conduit and Electrical Metallic Tubing
4. ANSI C80.6 - Intermediate Metal Conduit, Zinc Coated
5. ANSI/NEMA OS 1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers and Box Supports
6. ANSI/NEMA OS 2 - Nonmetallic Outlet Boxes, Device Boxes, Covers and Box Supports

B. Federal Specifications (FS):

1. A-A-50553A - Fittings for Conduit, Metal, Rigid, (Thick-Wall and Thin-Wall (EMT) Type
2. A-A-55810 - Specification for Flexible Metal Conduit

C. NECA "Standards of Installation"

D. National Electrical Manufacturers Association (NEMA):

1. ANSI/NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing and Cable
2. RN 1 - Polyvinyl chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit, Rigid Aluminum Conduit, and Intermediate Metal Conduit
3. TC 2 - Electrical Polyvinyl Chloride (PVC) Conduit

E. NFPA 70 - National Electrical Code (NEC)

F. Underwriters Laboratories (UL): Applicable Listings

1. UL 6 - Rigid Metal Conduit
2. UL 360 - Liquid Tight Flexible Steel Conduit
3. UL514-B - Conduit Tubing and Cable Fittings
4. UL746A - Standard for Polymeric Materials - Short Term Property Evaluations
5. UL797 - Electrical Metal Tubing
6. UL1242 - Intermediate Metal Conduit

G. Definitions:

1. Fittings: Conduit connection or coupling.
2. Body: Enlarged fittings with opening allowing access to the conductors for pulling purposes only.
3. Mechanical Spaces: Enclosed areas, usually kept separated from the general public, where the primary use is to house service equipment and to route services. These spaces generally have exposed structures, bare concrete and non-architecturally emphasized finishes.
4. Finished Spaces: Enclosed areas where the primary use is to house personnel and the general public. These spaces generally have architecturally emphasized finishes, ceilings and/or floors.
5. Concealed: Not visible by the general public. Often indicates a location either above the ceiling, in the walls, in or beneath the floor slab, in column coverings, or in the ceiling construction.
6. Above Grade: Not directly in contact with the earth. For example, an interior wall located at an elevation below the finished grade shall be considered above grade but a wall retaining earth shall be considered below grade.
7. Slab: Horizontal pour of concrete used for a floor or sub-floor.

PART 2 - PRODUCTS

2.1 RIGID METALLIC CONDUIT (RMC) AND FITTINGS

A. Manufacturers:

1. Allied
2. LTV
3. Steelduct
4. Calbond Calpipe
5. Wheatland Tube Co
6. O-Z Gedney
7. or approved equal.

B. Manufacturers of RMC Conduit Fittings:

1. Appleton Electric
2. O-Z/Gedney Co.
3. Electroline
4. Raco
5. Bridgeport
6. Midwest
7. Regal
8. Thomas & Betts
9. Crouse-Hinds
10. Killark
11. Orbit Industries
12. or approved equal.

C. Minimum Size Galvanized Steel: 3/4 inch, unless otherwise noted.

D. Fittings and Conduit Bodies:

1. End Bell Fittings: Malleable iron, hot dip galvanized, threaded flare type with provisions for mounting to form.
2. Expansion Joints: Malleable iron and hot dip galvanized providing a minimum of 4 inches of movement. Fitting shall be watertight with an insulating bushing and a bonding jumper.
3. Expansion Joint for Concrete Encased Conduit: Neoprene sleeve with bronze end coupling, stainless steel bands and tinned copper braid bonding jumper. Fittings shall be watertight and concrete-tight.
4. Conduit End Bushings: Malleable iron type with molded-on high impact phenolic thermosetting insulation. Where required elsewhere in the contract documents, bushing shall be complete with ground conductor saddle and clamp. High impact phenolic threaded type bushings are not acceptable.
5. All other fittings and conduit bodies shall be of malleable iron construction and hot dip galvanized.

E. PVC Externally Coated Conduit: Compliant with UL 6, ANSI C80.1 and NEMA RN 1; rigid galvanized steel conduit with external 40 mil PVC coating and internal 2 mil urethane coating surface. All fittings and conduit bodies shall be complete with coating. Threads shall be hot galvanized and coated with a clear coat of urethane. The PVC coated system shall include necessary PVC coated fittings, boxes and covers to form a complete encapsulated system.

1. Acceptable Manufacturers:

a. Calbond Calpipe
b. Robroy
c. T&B Ocal
d. or approved equal.

2.2 ELECTRICAL METALLIC TUBING (EMT) AND FITTINGS

A. Minimum Size Electrical Metallic Tubing: 3/4 inch, unless otherwise noted.

B. Manufacturers of EMT Conduit:

1. Allied
2. Calbond Calpipe
3. LTV
4. Steelduct
5. Wheatland Tube Co
6. or approved equal.

C. Fittings and Conduit Bodies:

1. 2" Diameter or Smaller: Compression or steel set screw type of steel designed for their specific application.
2. 1/2" and 3/4" Conduit: Push-on connectors and couplers with locking ring and washer of zinc plated steel, listed for use in dry locations.
3. Larger than 2": Compression type of steel designed for their specific application.
4. Manufacturers of EMT Conduit Fittings:

a. Appleton Electric
b. O-Z/Gedney Co.
c. Electroline
d. Raco
e. Bridgeport
f. Midwest
g. Regal
h. Thomas & Betts
i. Orbit Industries
j. or approved equal.

2.3 LIQUIDTIGHT FLEXIBLE METALLIC CONDUIT (LFMC) AND FITTINGS

A. Manufacturers:

1. Anaconda Type UA
2. Electri-Flex Type LA
3. Alflex
4. Carlon (Lamson & Sessions)
5. or approved equal.

B. Construction: Flexible steel, approved for conduit ground, zinc coated, threadless type formed from a continuous length of spirally wound, interlocked zinc coated strip steel and an extruded PVC cover.

C. Fittings and Conduit Bodies:

1. Watertight, compression type, galvanized zinc coated cadmium plated malleable cast iron, UL listed.
2. Fittings and conduit bodies shall include plastic or cast metal inserts supplied by the manufacturer to protect conductors from sharp edges.
3. Manufacturers:

a. Appleton Electric
b. O-Z/Gedney Co.
c. Electroline
d. Bridgeport
e. Thomas & Betts
f. Midwest
g. Regal
h. Carlon (Lamson & Sessions)
i. Orbit Industries
j. or approved equal.

2.4 RIGID NON-METALLIC CONDUIT (PVC) AND FITTINGS

A. Minimum Size Rigid Smooth-Wall Nonmetallic Conduit: 3/4 inch, unless otherwise noted.

B. Acceptable Manufacturers:

1. Carlon (Lamson & Sessions) Type 40
2. Cantex, J.M. Mfg.
3. or approved equal.

C. Construction: Schedule 40 and Schedule 80 rigid polyvinyl chloride (PVC), UL labeled for 90°C.

D. Fittings and Conduit Bodies: NEMA TC 3; sleeve type suitable for and manufactured especially for use with the conduit by the conduit manufacturer.

E. Plastic cement for joining conduit and fittings shall be provided as recommended by the manufacturer.

ASTM Test	Description	Values HDPE
D-1505	Density g/CM 3	less than 0.941
D-1238	Melt Index, g/10 min Condition E	greater than 0.55 grams/10 min.
D-638	Tensile Strength at yield (psi)	3000 min.
D-1693	Environmental Stress Crack Resistance Condition B, F 20	96 hrs.
D-790	Flexural Modulus, MPa (psi)	less than 80,000
D-746	Brittleness Temperature	-75°C Max

2.5 OUTLET BOXES

A. Sheet Metal Outlet Boxes: ANSI/NEMA OS 1; galvanized steel, 16 gauge (approximately 0.0625 inches), with 1/2-inch male fixture studs where required.

B. Nonmetallic Outlet Boxes: ANSI/NEMA OS 2.

C. Cast Boxes: Nema FB1, Type FD, Aluminum, cast feralloy, or stainless steel deep type, gasketed cover, threaded hubs.

D. Outlet boxes for luminaires to be not less than 1-1/2" deep, deeper if required by the number of wires or construction. The box shall be coordinated with surface luminaires to conceal the box from view or provide a finished trim plate.

E. Switch outlet boxes for local light control switches, dimmers and occupancy sensors shall be 4 inches square by 2-1/8 inches deep, with raised cover to fit flush with finish wall line. Multiple gang switch outlets shall consist of the required number of gang boxes appropriate to the quantity of switches comprising the gang. Where walls are plastered, provide a plaster raised cover. Where switch outlet boxes occur in exposed concrete block walls, boxes shall be installed in the block cavity with a raised square edge tile cover of sufficient depth to extend out to face of block or masonry boxes.

F. Outlet boxes for telephone substations in walls and columns shall be 4 inches square and 2-1/8 inches deep with single gang raised cover to fit flush with finished wall line equipped with flush telephone plate.

G. Wall or column receptacle outlet boxes shall be 4 inches square with raised cover to fit flush with finished wall line. Boxes in concrete block walls shall be installed the same as for switch boxes in block walls.

2.6 ECONN; ELECTRICAL CONNECTION

A. Electrical connection to equipment and motors, sized per Electrical Code. Coordinate requirements with contractor furnishing equipment or motor. Refer to specifications and general installation notes for terminations to motors.

2.7 JB; PULL AND JUNCTION BOXES

A. Sheet Metal Boxes: ANSI/NEMA OS 1; galvanized steel.

B. Sheet metal boxes larger than 12 inches in any dimension that contain terminations or components: Continuous hinged enclosure with 1/4 turn latch and white back panel for mounting terminal blocks and electrical components.

C. Cast Metal Boxes for Outdoor and Wet Location Installations: NEMA 250; Type 4 and Type 6, flat-flanged, surface-mounted junction box, UL listed as raintight. Galvanized cast iron box and cover with ground flange, neoprene gasket, and stainless steel cover screws.

D. Cast Metal Boxes for Underground Installations: NEMA 250; Type 4, inside flanged, recessed cover box for flush mounting, UL listed as raintight. Galvanized cast iron box and plain cover with neoprene gasket and stainless steel cover screws.

E. Flanged type boxes shall be used where installed flush in wall.

2.8 ACCESSORIES

A. Fire Rated Moldable Pads: UL #9700, moldable sheet putty at required thickness on all five sides of back boxes. Kinetics Noise Control - IsoBacker Pad, SpecSeal - SSP Putty and Pads, 3M #MPP-4S or equal.

B. Sound Barrier Insulation Pads: Mastic, non-hardening, sheet material, minimum 1/8" thickness applied to all five sides of back boxes. Kinetics Noise Control - SealTight Backer Pad, L.H. DOTTIE Co., #68 or equal.

PART 3 - EXECUTION

3.1 CONDUIT INSTALLATION SCHEDULE AND SIZING

A. In the event the location of conduit installation represents conflicting installation requirements as specified in the following schedule, a clarification shall be obtained from the Architect/Engineer. If this Contractor is unable to obtain a clarification as outlined above, concealed rigid galvanized steel conduit installed per these specifications and the Electrical Code shall be required.

B. Installation Schedule: Refer to drawings.

C. Size conduit as shown on the drawings and specifications. Where not indicated in the contract documents, conduit size shall be according to the Electrical Code. Conduit and conductor sizing shall be coordinated to limit conductor fill to less than 40%, maintain conductor ampere capacity as required by the Electrical Code (to include enlarged conductors due to temperature and quantity derating values) and to prevent excessive voltage drop and pulling tension due to long conduit/conductor lengths.

D. Minimum Conduit Size (Unless Noted Otherwise):

1. Above Grade: 3/4 inch. (The use of 1/2 inch would be allowed for installation conduit to individual light switches, individual receptacles and individual fixture whips from junction box.)
2. Below Grade 5' or less from Building Foundation: 1 inch.
3. Below Grade More than 5' from Building Foundation: 3/4 inch.
4. Telecommunication Conduit: 1 inch.
5. Controls Conduit: 3/4 inch.

E. Conduit sizes shall change only at the entrance or exit to a junction box, unless specifically noted on the drawings.

3.2 CONDUIT ARRANGEMENT

A. In general, conduit shall be installed concealed in walls, in finished spaces and where possible or practical, or as noted otherwise. Conduit shall be installed parallel or perpendicular to walls, ceilings, and exposed structural members. In unfinished spaces, mechanical and utility areas, conduit may run either concealed or exposed as conditions dictate and as practical unless noted otherwise on drawings. Installation shall maintain headroom in exposed vicinities of pedestrian or vehicular traffic.

B. Exposed conduit on exterior walls or above roof will not be allowed without prior written approval of Architect/Engineer. A drawing of the proposed routing and a photo of the location shall be submitted 14 days prior to start of conduit rough-in. Routing shall be shown on coordination drawings.

C. Conduit arrangement in elevated slabs (restricted to applications specifically noted or shown on drawings):

1. Conduit size shall not exceed one-third of the structural slab thickness. Place conduit between the top and bottom reinforcing with a minimum of 3" concrete cover.
2. Parallel conduits shall be spaced at least 8 inches apart. Exception: Within 18 inches of commonly served floor boxes, junction boxes, or similar floor devices. Arrange conduits parallel or perpendicular to building lines and walls.

D. Conduit shall not share the same cell as structural reinforcement in masonry walls.

E. Conduit runs shall be routed as shown on large scale drawings. Conduit routing on drawings scaled 1/4"=1'-0" or less shall be considered diagrammatic, unless noted otherwise. The correct routing, when shown diagrammatically shall be chosen by the Contractor based on information in the contract documents, in accordance with manufacturer's written instructions, applicable codes, the NECA's "Standard of Installation", in accordance with recognized industry standards, and coordinated with other contractors.

F. Contractor shall adapt Contractor's work to the job conditions and make such changes as required and permitted by the Architect/Engineer, such as moving to clear beams and joists, adjusting at columns, avoiding interference with windows, etc., to permit the proper installation of other mechanical and/or electrical equipment.

G. Contractor shall cooperate with all contractors on the project. Contractor shall obtain details of other contractor's work to ensure fit and avoid conflict. Any expense due to the failure of This Contractor to do so shall be paid for in full by Contractor. The other trades involved as directed by the Architect/Engineer shall perform the repair of work damaged as a result of neglect or error by This Contractor. The resultant costs shall be borne by This Contractor.

3.3 CONDUIT SUPPORT

A. Conduit runs installed above a suspended ceiling shall be properly supported. In no case shall conduit rest on the suspended ceiling construction, nor utilize ceiling support system for conduit support.

   1. Support wire used to independently support raceway and wiring systems above suspending ceilings shall be supported on both ends, minimum 12 gauge suspended ceiling support wire, and distinguishable from ceiling support systems by color (field paint), tagging, or equivalent means.

B. Conduit shall <u>not</u> be supported from ductwork, water, sprinkler piping, or other non-structural members, unless approved by the Architect/Engineer. All supports shall be from structural slabs, walls, structural members, and bar joists, and coordinated with all other applicable contractors, unless noted otherwise.

C. Conduit shall be held in place by the correct size of galvanized one-hole conduit clamps, two-hole conduit straps, patented support devices, clamp back conduit hangers, or by other means if called for on the drawings.

D. Support individual horizontal raceways with separate, malleable-iron pipe hangers or clamps.

E. Spring-steel conduit clips specifically designed for supporting single conduits or tubing may be used in lieu of malleable-iron hangers for 1" and smaller raceways serving lighting and receptacle branch circuits above accessible ceilings and for securing raceways to slotted channel and angle supports.

F. Group conduits in parallel runs where practical and use conduit racks or trapeze hangers constructed of steel channel, suspended with threaded solid rods or wall mounted from metal channels with conduit straps or clamps. Provide space in each rack or trapeze for 25% additional conduits.

G. Do not exceed 25 lbs. per hanger and a minimum spacing of 2'-0" on center when attaching to metal roof decking (excludes concrete on metal deck). This 25 lbs. load and 2'-0" spacing include adjacent electrical and mechanical items hanging from deck. If the hanger restrictions cannot be achieved, supplemental framing off steel framing will need to be added.

H. Arrange supports in vertical runs so the weight of raceways and enclosed conductors is carried entirely by raceway supports, with no weight load on raceway terminals.

I. Supports for metallic conduit shall be no greater than 10 feet. A smaller interval may be used if necessitated by building construction, but in no event shall support spans exceed the Electrical Code requirements. Conduit shall be securely fastened within 3 feet of each outlet box, junction box, device box, cabinet, or fitting.

J. Supports of flexible conduit shall be within 12 inches of each outlet box, junction box, device box, cabinet, or fitting and at intervals not to exceed 4.5 feet.

K. Supports for non-metallic conduit shall be at sufficiently close intervals to eliminate any sag in the conduit. The manufacturer's recommendations shall be followed, but in no event shall support spans exceed the Electrical Code requirements.

L. Where conduit is to be installed in poured concrete floors or walls, provide concrete-tight conduit inserts securely fastened to forms to prevent conduit misplacement.

M. Finish:

1. Prime coat exposed steel hangers and supports. Hangers and supports in crawl spaces, pipe shafts, and above suspended ceiling spaces are not considered exposed.
2. Trim all ends of exposed field fabricated steel hangers, slotted channel and threaded rod to within 1" of support or fastener to eliminate potential injury to personnel unless shown otherwise on the drawings. Smooth ends and install elastomeric insulation with two coats of latex paint if exposed steel is within 6'-6" of finish floor and presents potential injury to personnel.

3.4 CONDUIT INSTALLATION

A. Conduit Connections:

1. Shorter than standard conduit lengths shall be cut square using industry standards. The ends of all conduits cut shall be reamed or otherwise finished to remove all rough edges.
2. Metallic conduit connections in slab on grade installation shall be sealed and one coat of rust inhibitor primer applied after the connection is made.
3. Where conduits with tapered threads cannot be coupled with standard couplings, then approved split or Erickson couplings shall be used. Running threads will not be permitted.
4. Install expansion/deflection joints where conduit crosses structure expansion/seismic joints.

B. Conduit terminations for all low voltage wiring shall have nylon bushings installed on each end of every conduit run.

C. Conduit Bends:

1. Use a hydraulic one-shot conduit bender or factory elbows for bends in conduit 2" in size or larger. All steel conduit bending shall be done cold; no heating of steel conduit shall be permitted.
2. All bends of rigid polyvinyl chloride conduit (PVC) shall be made with the manufacturer's approved bending equipment. The use of spot heating devices will not be permitted (i.e. blow torches).
3. A run of conduit shall not contain more than the equivalent of four (4) quarter bends (360°), including those bends located immediately at the outlet or body.
4. Telecommunications conduits shall have no more than two (2) 90-degree bends between pull points and contain no continuous sections longer than 100 feet. Insert pull points or pull boxes for conduits exceeding 100 feet in length.

    a. A third bend is acceptable if:

        1) The total run is not longer than (33) feet.
        2) The conduit size is increased to the next trade size.

5. Telecommunications pull boxes shall not be used in lieu of a bend. Align conduits that enter the pull box from opposite ends with each other. Pull box size shall be twelve (12) times the diameter of the largest conduit. Slip sleeves or gutters can be used in place of a pull box.
6. Telecommunications Conduit(s): Maintain appropriate conduit bend radius at all times. For conduits with an internal diameter of less than 2", maintain a bend radius of at least 6 times the internal diameter. For conduits with an internal diameter 2" or greater, maintain a bend radius of at least 10 times the internal diameter.

7. Rigid polyvinyl chloride conduit (PVC) runs longer than 100 feet or runs which have more than two 90° equivalent bends (regardless of length) shall use rigid metal or RTRC factory elbows for bends.
8. Use conduit bodies to make sharp changes in direction (i.e. around beams).

D. Conduit Placement:

1. Conduit shall be mechanically continuous from source of current to all outlets. Conduit shall be electrically continuous from source of current to all outlets, unless a properly sized grounding conductor is routed within the conduit. All metallic conduits shall be bonded per the Electrical Code.
2. Route exposed conduit and conduit above suspended ceilings (accessible or not) parallel/perpendicular to the building structural lines, and as close to building structure as possible. Wherever possible, route horizontal conduit runs above water and steam piping.
3. Route conduit through roof openings provided for piping and ductwork where possible. If not provided or routing through provided openings is not possible, route through roof jack with pitch pocket. Coordinate roof penetrations with other trades.
4. Conduits, raceway, and boxes shall not be installed in concealed locations in metal deck roofing or less than 1.5" below bottom of roof decking.
5. Avoid moisture traps where possible. Where unavoidable, provide a junction box with drain fitting at conduit low point.
6. All conduits through walls shall be grouted or sealed into openings. Where conduit penetrates firewalls and floors, seal with a UL listed sealant. Seal penetrations with intumescent caulk, putty, or sheet installed per manufacturer's recommendations. All materials used to seal penetrations of firewalls and floors shall be tested and certified as a system per ASTM E814 Standard for fire tests or through-penetration fire stops as manufactured by 3M or approved equal.
7. CONTRACTOR SHALL BE RESPONSIBLE FOR ALL OPENINGS REQUIRED IN MASONRY OR EXTERIOR WALLS UNDER THIS DIVISION. A QUALIFIED MASON AT THE EXPENSE OF THIS CONTRACTOR SHALL REPAIR ALL OPENINGS TO MATCH EXISTING CONDITIONS.
8. Seal interior of conduit at exterior entries, air handling units, coolers/freezers, etc., and where the temperature differential can potentially be greater than 20°F, to prevent moisture penetration. Seal shall be placed where conduit enters warm space. Conduit seal fitting shall be a drain/seal, with sealing compound, identified for use with cable and raceway system, equal to O-Z/Gedney type EYD.
9. Horizontal conduit routing through slabs above grade

   a. No conduits are allowed to be routed horizontally through slabs above grade.

10. Do not route conduits across each other in slabs on grade.
11. Contractor shall provide suitable mechanical protection around all conduits stubbed out from floors, walls or ceilings during construction to prevent bending or damaging of stubs due to carelessness with construction equipment.
12. Contractor shall provide a polypropylene pull cord with 2000 lbs. tensile strength in each empty conduit (indoor and outdoor), except in sleeves and nipples.
13. Telecommunications conduits that protrude through the structural floor shall be installed 1 to 3" above finished floor (AFF).
14. Telecommunications conduits that enter into Telecommunications rooms below the finished ceiling shall terminate a minimum of 4" below ceiling and as close to the wall as possible.
15. Telecommunications conduits that are below grade and enter into a building shall terminate a minimum of 4" above finished floor (AFF) and as close to the wall as possible.

3.5 CONDUIT TERMINATIONS

A. Where conduit bonding is indicated or required in the contract documents, the bushings shall be a grounding type sized for the conduit and ground bonding conductor as manufactured by O-Z/Gedney, Appleton, Thomas & Betts, Burndy, Regal, Orbit Industries or approved equal.

B. Conduits with termination fittings shall be threaded for one (1) lock nut on the outside and one (1) lock nut and bushing on the inside of each box.

C. Where conduits terminate in boxes with knockouts, they shall be secured to the boxes with lock nuts and provided with approved screw type tinned iron bushings or fittings with plastic inserts.

D. Where conduits terminate in boxes, fittings, or bodies with threaded openings, they shall be tightly screwed against the shoulder portion of the threaded openings.

E. Conduit terminations to all motors shall be made with flexible metallic conduit (FMC), unless noted otherwise. Final connections to roof exhaust fans, or other exterior motors and motors in damp or wet locations shall be made with liquidtight flexible metallic conduit (LFMC). Motors in hazardous areas, as defined in the Electrical Code, shall be connected using flexible conduit rated for the environment. Flexible conduit shall not exceed 6' in length. Route equipment ground conductors from circuit ground to motor ground terminal through flexible conduit.

F. Rigid polyvinyl chloride conduit (PVC) shall be terminated using fittings and bodies produced by the manufacturer of the conduit, unless noted otherwise. Prepare conduit as per manufacturer's recommendations before joining. All joints shall be solvent welded by applying full even coat of plastic cement to the entire areas that will be joined. Turn the conduit at least a quarter to one half turn in the fitting and let the joint cure for 1-hour minimum or as per the manufacturer's recommendations.

G. All conduit ends shall be sealed with plastic immediately after installation to prevent the entrance of any foreign matter during construction. The seals shall be removed and the conduits blown clear of all foreign matter prior to any wires or pull cords being installed.

3.6 UNDERGROUND CONDUIT INSTALLATION

A. Conduit Connections:

1. Conduit joints in a multiple conduit run shall be staggered at least one foot apart.

B. Conduit Bends (Lateral):

1. Conduits shall have long sweep radius elbows instead of standard elbows wherever special bends are indicated and noted on the drawings, or as required by the manufacturer of the equipment or system being served.
2. Telecommunications conduit bend radius shall be six times the diameter for conduits under 2" and ten times the diameter for conduits over 2". Where long cable runs are involved, sidewall pressures may require larger radius bends. Coordinate with Architect/Engineer prior to conduit installation to determine bend radius.

C. Conduit Elbows (vertical):

1. Minimum metal or RTRC elbow radiuses shall be 30 inches for primary conduits (greater than 600V) and 18 inches for secondary conduits (less than 600V). Increase radius, as required, based on pulling tension calculation requirements.

D. Conduit Placement:

1. Conduit runs shall be pitched a minimum of 4" per 100 feet to drain toward the terminations. Duct runs shall be installed deeper than the minimum wherever required to avoid any conflicts with existing or new piping, tunnels, etc.
2. For parallel runs, use suitable separators and chairs installed not greater than 4' on centers. Band conduit together with suitable banding devices. Securely anchor conduit to prevent movement during concrete placement or backfilling.
3. Where concrete is required, the materials for concreting shall be thoroughly mixed to a minimum f'c = 2500 and immediately placed in the trench around the conduits. No concrete that has been allowed to partially set shall be used.
4. Before the Contractor pulls any cables into the conduit, Contractor shall have a mandrel 1/4" smaller than the conduit inside diameter pulled through each conduit and if any concrete or obstructions are found, the Contractor shall remove them and clear the conduit. Spare conduit shall also be cleared of all obstructions.
5. Conduit terminations in manholes, masonry pull boxes, or masonry walls shall be with malleable iron end bell fittings.

6. All spare conduits not terminated in a covered enclosure shall have its terminations plugged as described above.
7. Ductbanks and conduit shall be installed a minimum of 24" below finished grade, unless otherwise noted on the drawings or elsewhere in these specifications.
8. All non-metallic conduit installed underground outside of a slab shall be rigid.

E. Horizontal Directional Drilling:

1. Entire drill path shall be accurately surveyed, with entry and exit stakes placed and coordinated with other contractors. If using a magnetic guidance system, entire drill path shall be surveyed for any surface geo-magnetic variations or anomalies.
2. Any utility locates within 20 feet of the bore path shall have the exact location physically verified by hand digging or vacuum excavation. Restore inspection holes to original condition after verification.

F. Raceway Seal:

1. Where a raceway enters a building or structure, it shall be sealed with a sealing bushing or duct seal to prevent the entry of liquids or gases. Seal must be compatible with conductors and raceway system. Spare or unused raceway shall also be sealed.
2. All telecommunications conduits and innerducts, including those containing cables, shall be plugged at the building and vault with "JackMoon" or equivalent duct seal, capable of withstanding a 10-foot head of water (5 PSI).
3. Duct Seal Alternative Option: Inflatable duct seal system. Capable of withstanding a 10-foot head of water (5 PSEI).

   a. Manufacturers:

      1) Raychem Rayflate Duct Sealing Systems RDSS
      2) Approved equal

3.7 BOX INSTALLATION SCHEDULE

A. Galvanized steel boxes may be used in:

1. Concealed interior locations above ceilings and in hollow studded partitions.
2. Exposed interior locations in mechanical rooms and in rooms without ceilings; higher than 8' above the highest platform level.
3. Direct contact with concrete except slab on grade.

B. Cast boxes shall be used in:

1. Exterior locations.
2. Hazardous locations.
3. Exposed interior locations within 8' of the highest platform level.
4. Direct contact with earth.
5. Direct contact with concrete in slab on grade.
6. Wet locations.

3.8 COORDINATION OF BOX LOCATIONS

A. Provide electrical boxes as shown on the drawings, and as required for splices, taps, wire pulling, equipment connections, and code compliance.

B. Electrical box locations shown on the Contract Drawings are approximate, unless dimensioned. Verify location of floor boxes and outlets in offices and work areas prior to rough-in.

C. Locate and install boxes to allow access. Avoid interferences with ductwork, piping, structure, equipment, etc. Recessed luminaires shall not be used as access to outlet, pull, and junction boxes. Where installation is inaccessible, provide access doors. Coordinate locations and sizes of required access doors with the Architect/Engineer and General Contractor.

D. Locate and install to maintain headroom and to present a neat appearance.

E. Coordinate locations with Heating Contractor to avoid baseboard radiation cabinets.

3.9 OUTLET BOX INSTALLATION

A. Do not install boxes back-to-back in walls.

1. Provide a minimum horizontal separation of 6 inches between boxes installed on opposite sides of non-rated stud walls. When the minimum separation cannot be maintained, install sound insulation pads on all five sides of the back box in accordance with the manufacturer's instructions.
2. Provide a minimum horizontal separation of 24 inches between boxes installed on opposite sides of fire-rated walls. When the minimum separation cannot be maintained, the box is greater than 16 square inches or the total box area (all trades) per 100 square feet is greater than or equal to 100 square inches, install fire-rated moldable pads to all five sides of the back box to maintain the fire rating of the wall. Install moldable pads in accordance with UL listing for the specific product. Sound insulation pads are not acceptable for use in fire-rated wall applications unless the product carries the necessary fire rating.

B. Install sound insulation pads on all five sides of the back of all boxes in sound-rated wall assemblies. Sound-rated wall assemblies are defined as partition types carrying a Sound Transmission Class (STC) rating.

C. The Contractor shall anchor switch and outlet box to wall construction so that it is flush with the finished masonry, paneling, drywall, plaster, etc. The Contractor shall check the boxes as the finish wall surface is being installed to assure that the box is flush. (Provide plaster rings as necessary.)

D. Mount at heights shown or noted on the drawings or as generally accepted if not specifically noted.

E. Locate boxes in masonry walls to require cutting of masonry unit corner only. Coordinate masonry cutting to achieve neat openings for boxes.

F. Provide knockout closures for unused openings.

G. Support boxes independently of conduit.

H. Use multiple-gang boxes where more than one device is mounted together; do not use sectional boxes. Provide barriers to separate wiring of different voltage systems.

I. Install boxes in walls without damaging wall insulation.

J. Coordinate mounting heights and locations of outlets mounted above counters, benches, backsplashes, and below baseboard radiation.

K. Position outlets to locate luminaires as shown on reflected ceiling drawings.

L. Provide recessed outlet boxes in finished areas; secure boxes to interior wall and partition studs, accurately positioned to allow for surface finish thickness. Use stamped steel stud bridges for flush outlets in hollow stud wall, and adjustable steel channel fasteners for flush ceiling outlet boxes.

M. Align wall-mounted outlet boxes for switches, thermostats, and similar devices.

N. Provide cast outlet boxes in exterior locations and wet locations, and where exposed rigid or intermediate conduit is used.

3.10 PULL AND JUNCTION BOX INSTALLATION

A. Locate pull boxes and junction boxes above accessible ceilings or in unfinished areas.

B. Support pull and junction boxes independent of conduit.

C. Do not install boxes back-to-back in walls.

1. Provide a minimum horizontal separation of 6 inches between boxes installed on opposite sides of non-rated stud walls. When the minimum separation cannot be maintained, install sound insulation pads on all five sides of the back box in accordance with the manufacturer's instructions.
2. Provide a minimum horizontal separation of 24 inches between boxes installed on opposite sides of fire-rated walls. When the minimum separation cannot be maintained, the box is greater than 16 square inches or the total box area (all trades) per 100 square feet is greater than or equal to 100 square inches, install fire-rated moldable pads to all five sides of the back box to maintain the fire rating of the wall. Install moldable pads in accordance with UL listing for the specific product. Sound insulation pads are not acceptable for use in fire-rated wall applications unless the product carries the necessary fire rating.

D. Install sound insulation pads on all five sides of the back of all boxes in sound-rated wall assemblies. Sound-rated wall assemblies are defined as partition types carrying a Sound Transmission Class (STC) rating.

3.11 EXPOSED BOX INSTALLATION

A. Boxes shall be secured to the building structure with proper size screws, bolts, hanger rods, or structural steel elements.

B. On brick, block and concrete walls or ceilings, exposed boxes shall be supported with no less than two (2) Ackerman-Johnson, Paine, Phillips, or approved equal screw anchors or expansion shields and round head machine screws. Cast boxes shall not be drilled.

C. On steel structures, exposed boxes shall be supported to the steel member by drilling and tapping the member and fastening the boxes by means of round head machine screws.

D. Boxes may be supported on steel members by APPROVED beam clamps if conduit is supported by beam clamps.

E. Boxes shall be fastened to wood structures by means of a minimum of two (2) wood screws adequately large and long to properly support. (Quantity depends on size of box.)

F. Wood, plastic, or fiber plugs shall not be used for fastenings.

G. Explosive devices shall not be used unless specifically allowed.

END OF SECTION 26 05 33

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SECTION 26 05 35 - SURFACE RACEWAYS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Surface metal raceways

1.2 REFERENCES

A. FS W-C-582 - Conduit, Raceway, Metal, and Fitting; Surface

1.3 SUBMITTALS

A. Submit shop drawings under provisions of Section 26 05 00.

B. Include product data for surface metal raceways, multi-outlet assemblies, surface non-metallic raceways, auxiliary gutters, and accessories.

PART 2 - PRODUCTS

2.1 SURFACE METAL RACEWAY

A. Surface Metal Raceway: FS W-C-582; sheet metal channel with fitted cover, suitable for use as a continuous surface metal raceway.

B. Finish: Rust inhibiting primer coat for field painting. Coordinate paint color with Architect.

C. Fittings: Couplings, elbows, and connectors designed for use with raceway system.

D. Boxes and Extension Rings: Designed for use with raceway systems.

E. Coverplates shall be same material and finish as raceway.

F. Normal power receptacles shall be same color as raceway. Coordinate color with Architect.

G. Receptacles and outlets shown on raceway on drawings shall be mounted with overlapping faceplates in the raceway and shall not be mounted in boxes unless specifically noted otherwise.

H. WW-1; Surface metal raceway, metallic cover, minimum 4" opening, power / communication divider, minimum 7.5 square inch capacity./ must accommodate 30 amp receptacle installation

1. Manufacturers

   a. Wiremold AL4800
   b. Mono-Systems
   c. Hubbell HBL4750 Series.

I. WW-2 Surface metal raceway, metallic cover, minimum 4" opening, power / communication divider, minimum 16.6 square inch capacity.

1. Manufacturers:

   a. Wiremold G6000/G4048
   b. Mono-Systems SMS4400
   c. Hubbell HBL6750 Series.

PART 3 - EXECUTION

3.1 INSTALLATION - SURFACE METAL RACEWAY

A. Use flat-head screws to fasten channel to surfaces. Mount plumb and level.

B. Use suitable insulating bushings and inserts at connections to outlets and corner fittings.

C. Maintain grounding continuity between raceway components to provide a continuous grounding path.

D. Fastener: Use clips and straps suitable for the purpose.

E. Field cuts to be clean and straight and use the proper tools as recommended by the system manufacturer to prohibit damage to factory finish or raceway. Joints to be matched so there are no gaps or spaces in the cover. Furnish and install manufacturer's raceway accessories as needed.

F. Provide conduits to technology raceway per drawings or provide a minimum of one (1) 1-1/4" conduit per six feet of assembly (minimum 2) to above ceiling for technology requirements if assembly has technology raceway (Contractor shall provide quantities of conduits that provide maximum capacity to assembly). Provide conduits equally spaced within entire length of assembly.

G. Provide one (1) 3/4" empty conduit per six feet of assembly (minimum 1) to above ceiling for future power needs. Provide conduits equally spaced within entire length of assembly.

END OF SECTION 26 05 35

SECTION 26 05 48 - SEISMIC REQUIREMENTS FOR EQUIPMENT AND SUPPORTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Seismic Requirements.

1.2 QUALITY ASSURANCE

A. General:

1. The contractor shall retain a specialty consultant or equipment manufacturer to develop a seismic restraint and support system and perform seismic calculations in accordance with these specifications, state, and local codes.
2. Items used for seismic restraint of equipment and systems shall be specifically manufactured for seismic restraint.
3. These requirements are beyond those listed in Section 26 05 27 of these specifications. Where a conflict arises between the seismic requirements of this section and any other section, the Architect/Engineer shall be immediately notified for direction to proceed.

B. Manufacturer:

1. System Supports/Restraints: Company specializing in the manufacture of products specified in this Section.
2. Equipment: Each company providing equipment that must meet seismic requirements shall provide certification included in project submittals the equipment supplied for the project meets or exceeds the seismic requirements of the project.

C. Testing Agency: An independent testing agency, acceptable to Authorities Having Jurisdiction, with experience and capability to conduct the testing indicated.

D. Installer: Company specializing in performing the work of this Section.

1.3 REFERENCES

A. International Building Code, .

B. ASHRAE - A Practical Guide to Seismic Restraint.

C. ASCE 7-16, Chapter 13.

1.4 SUBMITTALS

A. Submit under provisions of Section 26 05 00.

B. Submittal to Code Official:

1. Contractor shall submit copies of the seismic shop drawings to the governing code authority for approval.

C. Shop Drawings:

1. Calculations, restraint selections, and installation details shall be designed and sealed by a Professional Engineer licensed in the state where the project is located experienced in seismic restraint design and installation.
2. Coordination Drawings: Plans and sections drawn to scale, coordinating seismic bracing of electrical components with other systems and equipment in the vicinity, including other seismic restraints.
3. Manufacturer's Certifications: Professional Engineer licensed in the state where the project is located shall review and approve manufacturer's certifications of compliance.
4. System Supports/Restraints - Submit for each condition requiring seismic bracing:

   a. Calculations for each seismic brace and detail utilized on the project.
   b. Plan drawings showing locations and types of seismic braces on contractor fabrication/installation drawings.
   c. Cross-reference between details and plan drawings to indicate exactly which brace is being installed at each location. Details provided are to clearly indicate attachments to structure, correctly representing the fastening requirements of bracing.
   d. Clear indication of brace design forces and maximum potential component forces at attachment points to building structure for confirmation of acceptability by the Structural Engineer of Record.

5. Equipment - Submit for each piece of equipment supplied:

   a. Certification that the equipment supplied for the project meets or exceeds the seismic requirements specified. Equipment certification is to be provided by the manufacturer
   b. Specific details of seismic design features of equipment and maximum seismic loads imparted to the structural support.
   c. Engineering calculations and details for equipment anchorage and support structure.

D. A seismic restraint designer shall be provided whether or not exceptions listed in the applicable building code are met. If seismic restraints are not provided for a system that requires seismic bracing, the seismic designer shall submit a signed and sealed letter to the Architect/Engineer and Authorities Having Jurisdiction stating the exceptions, along with code reference, utilized for each item. Seismic designer shall review system installation for general conformance to the exception requirements stated in the code and document, in writing, the system has been installed in accordance to the exception.

1.5 TESTING AND INSPECTION

A. Special Inspection and Testing shall be done in accordance with Chapter 17 of the International Building Code.

B. The Owner shall employ a Special Inspection Agency to perform the duties and responsibilities specified in Section 1704 and 1705.

C. Work performed on the premises of a fabricator approved by the building official need not be tested and inspected. The fabricator shall submit a certificate of compliance that the work has been performed in accordance with the approved plans and specifications to the building official and the Architect and Engineer of Record.

D. The Special Inspection Agency shall furnish inspection reports to the building official, the Owner, the Architect, the Engineer of Record, and the General Contractor. The reports shall be completed and furnished within 48 hours of inspected work. A final signed report stating whether the work requiring special inspection was, to the best of the Special Inspection Agency's knowledge, in conformance with the approved plans and specifications shall be submitted.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site. Accept material on site in factory containers and packing. Inspect for damage. Protect from damage and contamination by maintaining factory packaging until installation. Follow manufacturer's instructions for storage.

1.7 DESIGN REQUIREMENTS

A. This project is subject to the seismic bracing requirements of the International Building Code, 2012 edition.

B. The following criteria are applicable to this project:

1. Risk Category: II
2. Seismic Importance Factor: $I_E = 1.0$
3. Seismic Design Category: D
4. Component Amplification Factors (ap) and Component Response Modification Factors (Rp) shall be taken from Table 13.5-1 in ASCE 7-10 for the individual equipment or system being restrained.
5. Component Importance Factors (Ip) shall be taken from Section 13.1.3 in ASCE 7-10 for the individual equipment or system being restrained.
6. The total height of the structure and the height of the system to be restrained within the structure shall be determined in coordination with architectural plans and the General Contractor.

C. Forces shall be calculated with the above requirements and Equation 13.3-1, -2, and -3 of ASCE 7-10, unless exempted by 13.1.4.

D. Equipment shall meet International Building Code and ASCE 7 seismic qualification requirements in concurrence with ICC ES AC156 Acceptance Criteria for Seismic Qualification by Shake-Table Testing of Nonstructural Components and Systems.

E. All seismic anchorage and bracing shall comply with FM Global Property Loss Prevention Data Sheet 1-11, Fire Following Earthquakes.

1.8 COORDINATION

A. Coordinate layout and installation of seismic bracing with building structural systems and architectural features, and with mechanical, fire-protection, electrical and other building features in the vicinity.

B. Coordinate concrete bases with building structural system.

1.9 WARRANTY

A. Provide one-year warranty on parts and labor for manufacturer defects and installation workmanship.

PART 2 - PRODUCTS

2.1 SUPPLIERS

A. Following is a partial list of manufacturer/supplier contact information for seismic restraints:

1. B-Line Systems, Inc. (800) 851-7415, www.b-line.com.
2. Unistrut Corporation http://www.unistrut.us/
3. Kinetics Noise Control (877) 457-2695, www.kineticsnoise.com.
4. Mason Industries, Inc. www.mason-ind.com.

5. Loos & Co., Inc. (800) 321-5667, www.loosnaples.com.
6. Tolco (909) 737-5599, www.tolco.com
7. ISAT 877.523.6060, www.isatsb.com
8. Vibro-Acoustics (416) 291-7371, https://virs.vibro-acoustics.com/

2.2 SEISMIC DESIGN CRITERIA

A. This section describes the requirements for seismic restraint of systems and equipment related to continued operation of the facility after a design seismic event.

B. Definitions:

1. Stay in Place:

a. All systems and equipment shall be anchored and restrained such that the anchoring system is intended not to fail and equipment and/or system components will not fall.

2. Remain Operational:

a. Requirements for "Stay in Place" listed above shall be met.
b. The following systems and associated equipment are intended not to fail externally or internally and are intended to remain operational.

1) Life Safety Power
2) Emergency Power System
3) Fire Alarm

2.3 SEISMIC BRACING AND SUPPORT OF SYSTEMS AND COMPONENTS

A. General:

1. Seismic restraint designer shall coordinate all attachments with the Structural Engineer of Record; refer to submittal requirements.
2. The seismic restraint design shall be based on actual equipment data obtained from manufacturer's submittals or the manufacturer. The equipment manufacturer shall verify and provide written certification the attachment points on the equipment can accept the combination of seismic, weight, and other imposed loads.
3. Design analysis shall include calculated dead loads, static seismic loads, and capacity of materials utilized for the connection of the equipment or system to the structure.
4. Analysis shall detail anchoring methods, bolt diameter, embedment, and weld length.
5. All seismic restraint devices shall be designed to accept without failure the forces calculated per the applicable building code.
6. All seismic restraints and combination isolator/restraints shall have verification of their seismic capabilities witnessed by an independent testing agency.

B. Friction from gravity loads shall not be considered resistance to seismic forces.

C. Housekeeping Pads:

1. Reinforced housekeeping pads shall be provided to handle shear, tension, and compression forces with proper reinforcement, doweling, and attachments connecting the pad to the structural slab.

2.4 SEISMIC RESTRAINT AND CONSTRUCTION OF EQUIPMENT

A. Equipment supplied for the project shall be designed to meet the requirements of lateral forces calculated using the applicable code and method described above.

B. The following is a partial list of equipment that shall be restrained and that shall be constructed to meet seismic forces described in this section:

1. Switchboards, Distribution Panelboards, Panelboards, Load Centers
2. Emergency Feeders
3. Cable tray, Busway, Ductbank
4. Disconnect Switches
5. Magnetic, Manual, Combination Starters
6. Variable Frequency Drives
7. Automatic/Manual Transfer Switches
8. Interior Luminaires
9. Emergency Luminaires and Exit Signs
10. Fire Alarm Panel, Initiating and Notification Appliances
11. Area of Rescue Assistance
12. Security System

2.5 MATERIALS

A. Use the following materials for restraints:

1. Indoor Dry Locations: Steel, zinc plated.
2. Outdoors and Damp Locations: Galvanized steel.
3. Corrosive Locations: Stainless steel.

2.6 ANCHORAGE AND STRUCTURAL ATTACHMENT COMPONENTS

A. Strength: Defined in reports by ICC Evaluation Service or another agency acceptable to authorities having jurisdiction.

1. Structural Safety Factor: Strength in tension and shear of components used shall be at least two times the maximum seismic forces to which they will be subjected.

B. Concrete and Masonry Anchor Bolts and Studs: Steel-expansion wedge type. Comply with IBC, ACI and ICC ES requirements for cracked concrete anchors.

C. Concrete Inserts: Steel-channel type.

D. Through Bolts: Structural type, hex head, high strength. Comply with ASTM F3125, Grade A 325.

E. Welding Lugs: Comply with MSS SP-69, Type 57.

F. Beam Clamps for Steel Beams and Joists: Double sided. Single-sided type is not acceptable.

G. Bushings for Floor-Mounted Equipment Anchors: Neoprene units designed for seismically rated rigid equipment mountings, and matched to the type and size of anchor bolts and studs used.

H. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for seismically rated rigid equipment mountings, and matched to the type and size of attachment devices used.

2.7 SEISMIC BRACING COMPONENTS

A. Slotted Steel Channel: 1-5/8-by-1-5/8-inch cross section, formed from 0.1046-inch-thick steel, with 9/16-by-7/8-inch slots at a maximum of 2 inches o.c. in webs, and flange edges turned toward web.

1. Materials for Channel: ASTM A 1011, GR 33.

2. Materials for Fittings and Accessories: ASTM A 635, ASTM A 576, or ASTM A 36.
3. Fittings and Accessories: Products of the same manufacturer as channels and designed for use with that product.
4. Finish: Baked, rust-inhibiting, acrylic-enamel paint applied after cleaning and phosphate treatment, unless otherwise indicated.

B. Channel-Type Bracing Assemblies: Slotted steel channel, with adjustable hinged steel brackets and bolts.

C. Cable-Type Bracing Assemblies: Zinc-coated, high-strength steel wire rope cable attached to steel thimbles, brackets, and bolts designed for cable service.

1. Arrange units for attachment to the braced component at one end and to the structure at the other end.
2. Wire Rope Cable: Comply with ASTM A 603. Use 49- or 133-strand cable with a minimum strength of 2 times the calculated maximum seismic force to be resisted.

D. Hanger Rod Stiffeners: Slotted steel channels with internally bolted connections to hanger rod.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Refer to the applicable code sections and Authority Having Jurisdiction for the exact seismic restraint requirements of conduit, equipment, etc.

B. Layout of transverse and longitudinal bracing shall follow recommendations of approved design standards listed in Part 1 of this specification section.

C. All rigid floor mounted equipment shall have a resilient media between the equipment mounting hole and the anchor bolt in concrete.

D. All seismic restraint systems shall be installed in strict accordance with the manufacturer's written instructions and all certified submittal data.

E. Installation of seismic restraints shall not cause any change in position of equipment lighting or conduits resulting in stresses or misalignment.

F. No rigid connections between equipment and the building structure shall be made that degrade the noise and vibration-isolation system specified.

G. Do not install any equipment or conduit that makes rigid connections with the building unless isolation is not specified.

H. Coordinate work with all other trades to avoid rigid contact with the building. Any conflicts with other trades that will result in rigid contact with equipment or conduit due to inadequate space or other unforeseen conditions shall be brought to the Architect/Engineer's attention prior to specific equipment selection.

I. Prior to installation, bring to the Architect/Engineer's attention any discrepancies between the specifications and the field conditions, or changes required due to specific equipment selection.

J. Bracing may occur from flanges of structural beams, upper truss cords of bar joists, cast in place inserts, or International Code Council approved seismic anchors for installation in concrete.

K. Cable restraints shall be installed slightly slack to avoid short-circuiting the isolated suspended equipment or conduit.

L. Cable assemblies shall be installed taut on non-isolated systems. Solid braces may be used in place of cables on rigidly attached systems only.

M. Do not install cables over sharp corners.

N. Brace support rods when necessary to accept compressive loads. Welding of compression braces to the vertical support rods is not acceptable.

O. Provide reinforced clevis bolts when required.

P. The vibration isolation manufacturer shall furnish integral structural steel bases as required. Independent steel rails are not acceptable.

Q. Post-Installed anchors shall be provided to meet seismic requirements.

R. Vertical conduit risers flexibly supported to accommodate thermal motion and/or conduit vibration shall be guided to maintain conduit stability and provide horizontal seismic restraint.

S. Seismic restraints shall be mechanically attached to the system. Looping restraints around the system is not acceptable.

T. Conduit crossing building seismic or expansion joints, passing from building to building, or supported from different portions of the building shall be installed to allow differential support displacements without damaging the conduit, equipment connections, or support connections. Conduit offsets, loops, anchors, and guides shall be installed as required to provide required motion capability and limit motion of adjacent conduit.

U. Do not brace a system to two different structures such as a wall and a ceiling.

V. Provide appropriately sized openings in walls, floors, and ceilings for anticipated seismic movement. Provide fire seal systems in fire-rated walls.

W. Positively attach all roof-mounted equipment to roof curbs. Positively attach all roof curbs to building structure.

X. Exposed seismic supports in occupied areas shall be guarded or covered to protect occupants.

3.2 SEISMIC RESTRAINT EXCLUSIONS

A. Refer to the applicable code sections and Authority Having Jurisdiction for allowable exclusions.

END OF SECTION 26 05 48

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SECTION 26 05 53 - ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Adhesive Markings and Field Labels

B. Nameplates and Signs

C. Product Colors

1.2 REFERENCES

A. NFPA 70E - National Electrical Safety Code

B. NFPA 70 - National Electrical Code (NEC)

C. ANSI A13.1 - Standard for Pipe Identification

D. ANSI Z535.4 - Standard for Product Safety Signs and Labels

PART 2 - PRODUCTS

2.1 ADHESIVE MARKINGS AND FIELD LABELS

A. Colored Adhesive Marking Tape for banding Raceways, Wires, and Cables: Self-adhesive vinyl tape not less than 3 mils thick by 1 inch to 2 inches in width.

B. Pretensioned Flexible Wraparound Colored Plastic Sleeves for Cable Identification: flexible acrylic bands sized to suit the cable diameter and arranged to stay in place by pre-tensioned gripping action when coiled around the cable.

C. Wire/Cable Designation Tape Markers: Vinyl or vinyl-cloth, self-adhesive, wraparound, cable/conductor markers with preprinted numbers and letter.

D. Cable Ties: Fungus-inert, self-extinguishing, one-piece, self-locking nylon cable ties, 0.18-inch minimum width, 50-lb minimum tensile strength, and suitable for a temperature range from -40°F to 185°F (-40°C to 85°C), type 2/2S or type 21/21S based on application. Provide ties in specified colors when used for color coding. Cable ties shall be listed and identified for the application, securement, and support.

E. Underground Plastic Markers: Bright colored continuously printed plastic ribbon tape of not less than 6 inches wide by 4 mil thick, printed legend indicating type of underground line, manufactured for direct burial service. Tape shall contain a continuous metallic wire to allow location with a metal detector.

F. Aluminum, Wraparound Marker Bands: 1-inch width, 0.014 (5mm) inch thick aluminum bands with stamped or embossed legend, and fitted with slots or ears for permanently securing around wire or cable jacket or around groups of conductors.

G. Brass or Aluminum Tags: 2" (50mm) by 2" (50mm) by .05-inch metal tags with stamped legend, punched for fastener.

H. Indoor/Outdoor Number and Letters: Outdoor grade vinyl label with acrylic adhesive designed for permanent application in severe indoor and outdoor environments.

I. Text Sizes:

1. The following information shall be used for text heights, fonts, and size, unless otherwise noted.

a. Font: Normal 721 Swiss Bold
b. Adhesive Labels: 3/16 inch minimum text height
c. Vinyl / Plastic Laminate Labels: 3/4" inch minimum text height

2.2 NAMEPLATES AND SIGNS

A. Engraved, Plastic-Laminated Labels, Signs and Instruction Plates: Engraving stock melamine plastic laminate, 1/16-inch minimum thick for signs up to 20 square inches, or 8 inches in length; 1/8 inch thick for larger sizes. Labels shall be punched for mechanical fasteners.

B. Text Sizes:

1. The following information shall be used for text heights, fonts, and size, unless otherwise noted.

a. Text Height: 3/8 inch minimum

C. Baked-Enamel Signs for interior Use: Preprinted aluminum signs, punched, or drilled for fasteners, with colors, legend, and size required for application. Mounting ¼" grommets in corners.

D. Exterior, Metal-Backed, Butyrate Signs: Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396 inch galvanized-steel backing: and with colors, legend, and size required for application. Mounting 1/4" grommets in corners.

E. Safety Signs: Comply with 29 CFR, Chapter XVII, Part 1910.145.

F. Fasteners for Plastic-Laminated Signs; Self-tapping stainless steel screws or number 10/32 stainless steel machine screws with nuts and flat and lock washers.

2.3 PRODUCT COLORS

A. Adhesive Markings and Field Labels:

1. Normal Power and General Labels: Black letters on white face
2. Control Labels: Black letters on white face
3. Medium Voltage (greater than 1,000 volts): Black letters on white face
4. Fire Alarm: Red letters on white face
5. Emergency: Red letters on white face

B. Nameplates and Signs:

1. NORMAL POWER: Black letters on white face
2. Control Labels: Black letters on white face
3. EMERGENCY: White letters on red face
4. GROUNDING: White letters on green face.
5. CAUTION or UPS: Black letters on yellow face

C. Raceways and Conduit:

1. Provide color coded conduit as indicated below. Conduit shall be colored by the manufacturer:

a. Normal Power and General Distribution: Silver
b. Emergency Power Distribution System:

1) All Emergency: Orange
2) Legally Required Standby: Yellow
3) Optional Standby: Orange

c. Fire Alarm System: Red
d. Temperature Controls: Refer to mechanical cover sheet for color
e. Ground: Green
f. Low Voltage and Telephone: Purple
g. Clock, Sound, Security System, and Intercom: Black

D. Box Covers:

1. Box cover colors shall match conduit colors listed above.

E. Conductor Color Identification: Refer to Part 3 for additional information.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Lettering and Graphics: Coordinate names, abbreviations, colors, and other designations used in electrical identification work with corresponding designations specified or indicated. Install numbers, lettering, and colors as required by code.

B. Exposed Ceilings and Finished Spaces: The project includes exposed ceilings in finished spaces. The installation of colored raceways and labeling may not be aesthetically desirable in finished spaces. The contractor shall coordinate identification requirements in exposed ceilings of finished spaces with the A/E prior to installation and ordering of materials.

C. Electrical System Color Chart: This Contractor shall furnish and install framed 8" x 12" charts of the color-coded identification scheme used for the electrical system in all electrical rooms and next to the main fire alarm panel.

D. Install identification devices in accordance with manufacturer's written instruction and requirements of Electrical Code.

E. Sequence of Work: Where identification is to be applied to surfaces that require finish, install identification after completion of finish work. All mounting surfaces shall be cleaned and degreased prior to identification installation.

F. Circuit Identification: Tag or label conductors as follows:

1. Multiple Power or Lighting Circuits in Same Enclosure: Where multiple branch circuits are terminated or spliced in a box or enclosure, label each conductor with source and circuit number.
2. Multiple Control Wiring and Communication/Signal Circuits in Same Enclosure: For control and communications/signal wiring, use wire/cable marking tape at terminations in wiring boxes, troughs, and control cabinets. Use consistent letter/number conductor designations throughout on wire/cable marking tape.

3. Match identification markings with designations used in panelboards shop drawings, Contract Documents, and similar previously established identification schemes for the facility's electrical installations.

G. Apply warning, caution and instruction signs as follows:

1. Install warning, caution or instruction signs where required by Electrical Code, where indicated, or where reasonably required to assure safe operation and maintenance of electrical systems and of the items to which they connect. Install engraved plastic-laminated instruction signs with approved legend where instructions or explanations are needed for system or equipment operation. Install metal-backed butyrate signs for outdoor items.
2. Emergency Operating Signs: Install, where required by Electrical Code, where indicated, or where reasonably required to assure safe operation and maintenance of electrical systems and of the items to which they connect, engraved laminate signs with white legend on red background with minimum 3/8-inch high lettering for emergency instructions on power transfer, load shedding, or other emergency operations.

H. Apply circuit/control/item designation labels of engraved plastic laminate for pushbuttons, pilot lights, alarm/signal components, and similar items, except where labeling is specified elsewhere.

I. Install labels parallel to equipment lines at locations as required and at locations for best convenience of viewing without interference with operation and maintenance of equipment.

J. Install ARC FLASH WARNING signs on all power distribution equipment per Section 26 05 73.

K. Circuits with more than 600V: Identify raceway and cable with "DANGER-HIGH VOLTAGE" in black letters 2 (50mm) inches high on orange background at 10'-0 foot intervals.

1. Entire floor area directly above conduits running beneath and within 12 inches of a basement or ground floor that is in contact with earth or is framed above unexcavated space.
2. Wall surfaces directly external to conduits concealed within wall.
3. All accessible surfaces of concrete envelope around conduits in vertical shafts, exposed in building, or concealed above suspended ceilings.

L. Selective Coordination Label: Install caution signs on all switchboards, distribution panels, panelboards, disconnects, and other equipment with selectively coordinated overcurrent protection devices. Sign at a minimum shall contain:

1. CAUTION: OVERCURRENT DEVICES IN THIS ENCLOSURE ARE SELECTIVELY COORDINATED. EQUIVALENT REPLACEMENTS AND TRIP SETTINGS ARE REQUIRED.

3.2 LIGHTING CONTROL AND RECEPTACLE COVER PLATES

A. Product:

1. Adhesive labels and field markings

B. Identification material to be a clear, 3/8-inch Kroy tape or Brother self-laminating vinyl label with black letters. Embossed Dymo-Tape labels are not acceptable. Permanently affix identification label to cover plates, centered above the receptacle openings.

C. Provide identification on all switch and receptacle cover plates. Identification shall indicate source and circuit number serving the device (e.g. "C1A #24").

3.3 CONDUIT AND EXPOSED CABLE LABELING

A. Product:

1. Adhesive labels and field markings

B. Conduit Identification: Pre-printed, flexible, self-adhesive vinyl labels with legend at 25 foot (7.5 meter) intervals to identify all conduits run exposed or located above accessible ceilings. Conduits located above non-accessible ceiling or in floors and walls shall be labeled within 3 feet of becoming accessible, or separated by enclosures, walls, partitions, ceilings, and floors. Labels for multiple conduits shall be aligned. Refer to color requirements in Part 2 when applicable in addition to the following:

1. Medium Voltage (greater than 1,000 volt): Indicate feeder identification and voltage.
2. 1000 Volt or less Normal/Emergency Power: Indicate feeder identification and voltage.
3. Fire Alarm: Indicate "FIRE ALARM".
4. Grounding: Indicate "GROUND" and equipment and designation.
5. Security System: Indicate "Security".
6. Telephone System: Indicate "Telephone".

C. Blank conduit ends or outlet boxes for future extension of system shall have permanent identification marker indicating purpose of conduit or box and where the raceway originated.

3.4 BOX LABELING

A. Products:

1. Adhesive labels and field markings

B. Identify Junction, Pull and Connection Boxes: Labeling shall be 3/8-inch Kroy tape OR Brother self-laminating vinyl label, letters/numbers color coded same as conduits.

C. All junction, pull, and connection boxes shall be identified as follows:

1. For power and lighting circuits, indicate system voltage and identity of contained circuits ("120V, 1LA1-3,5,7").
2. For other wiring, indicate system type and description of wiring ("FIRE ALARM NAC #1").

3.5 CONDUCTOR COLOR CODING

A. Products:

1. All wire and cables shall be color coded by the manufacturer.

B. Color coding shall be applied at all panels, switches, junction boxes, pull boxes, vaults, manholes etc., where the wires and cables are visible and terminations are made. The same color coding shall be used throughout the entire electrical system, therefore maintaining proper phasing throughout the entire project.

C. Colored cable ties shall be applied in groups of three ties of specified color to each conductor at each terminal or splice point starting 3 inches from the termination and spaced at 3- inches centers. Tighten to a snug fit, and cut off excess length.

D. Where more than one nominal voltage system exists in a building or facility, each ungrounded conductor of a multi-wire branch circuit, where accessible, shall be identified by phase and system.

E. Conductors shall be color coded as follows:

1. 208Y/120 Volt, 4-Wire:

a. A-Phase - Black
b. B-Phase - Red
c. C-Phase - Blue
d. Neutral - White
e. Ground Bond - Green

2. 480Y/277 Volt, 4-Wire:

a. A-Phase - Brown
b. B-Phase - Orange
c. C-Phase - Yellow
d. Neutral - Gray
e. Ground Bond - Green

3. Grounding Conductors:

a. Equipment grounding conductors, main/system/supply-side bonding jumpers: Green.

4. Cabling for Remote Control, Signal, and Power Limited Circuits:

a. Fire Alarm: Refer to Fire Alarm and Automatic Detection Section 28 31 00 for cable color requirements.
b. Low Voltage Switching: Per manufacturer recommendations and code requirements.
c. Building Automation Systems and Control: Refer to the Temperature Control Contactor notes located on the mechanical cover sheet.
d. Electronic Control: Per manufacturer recommendations and code requirements.
e. Audio/Visual Systems: Refer to Division 27.
f. Structured Cabling: Refer to Division 27.

3.6 CONTROL EQUIPMENT IDENTIFICATION

A. Products:

1. Nameplates and signs

B. Provide identification on the front of all control equipment such as combination starters, starters, VFDs, contactors, motor control centers, etc.

C. Identification shall be provided for all connections to equipment furnished by this Contractor, other contractors, or the Owner.

D. Labeling shall include:

1. Equipment type and contract documents designation of equipment being served.
2. Location of equipment being served if it is not located within sight.
3. Voltage and phase of circuit(s).
4. Panel and circuit number(s) serving the equipment.
5. Method of automatic control, if included ("AUTO CONTROL BY FMCS").
6. Available fault current; refer to one-line diagram or panel schedule of panel serving equipment.
7. Date of fault current study, refer to one-line diagram

8. Sample Label:

   EXHAUST FAN EF-1 ("LOCATED ON ROOF")
   480V, 3-PHASE
   FED FROM "1HA1-1"
   AUTO CONTROL BY FMCS
   22,000 AMPS AVAILABLE FAULT CURRENT
   DATE OF STUDY: 1 JAN 2017

3.7 EQUIPMENT CONNECTION IDENTIFICATION

A. Products:

   1. Nameplates and signs

B. Provide identification for hard wired electrical connections to equipment such as disconnects switches, starters, etc. Plug and cord type connections do not require this specific label.

C. Identification shall be provided for all connections to equipment furnished by this Contractor, other contractors, or the Owner. [The following list of equipment is specifically being listed to receive an equipment connection label; this list does not limit the equipment that shall receive a label:]

   1. Mechanical heating, ventilation, and air conditioning equipment; chillers, boilers, pumps, air handing ventilation units, condensing units, unit heaters, and similar equipment
   2. Plumbing equipment
   3. Fire protection equipment including fire pumps
   4. Elevator

D. Labeling shall include:

   1. Equipment type and contract documents designation of equipment being served
   2. Location of equipment being served if it is not located within sight.
   3. Voltage and rating of the equipment.
   4. Panel and circuit numbers(s) serving the equipment
   5. Available fault current; refer to one-line diagram or panel schedule of panel serving equipment.
   6. Date of fault current study; refer to one-line diagram
   7. Sample Label:

      UNIT HEATER UH-1 ("LOCATED IN STORAGE ROOM 200")
      480V: 3-PHASE
      FED FROM "1HA1-1"
      22,000 AMPS AVAILABLE FAULT CURRENT
      DATE OF STUDY: 1 JAN 2017

3.8 POWER DISTRIBUTION EQUIPMENT IDENTIFICATION

A. Products:

   1. Nameplates and signs

B. Provide identification on the front of all power distribution equipment such as panelboards, switchboards, switchgear, motor control centers, generators, UPS, storage battery disconnects, transfer switches, etc. Labels shall be visible on the exterior of the gear, correspond to the one-line diagram nomenclature, and identify each cubicle of multi-section gear.

   1. Interior Equipment: The identification material shall be engraved plastic-laminated labels.
   2. Exterior Equipment: The identification material shall be engraved vinyl labels.

3. Labeling shall include:

   a. Equipment type and contract documents designation of equipment.
   b. Voltage of the equipment.
   c. Name of the upstream equipment and location of the upstream equipment if it is not located within sight.
   d. Rating and type of the overcurrent protection device serving the equipment if it is not located within sight ("FED BY 400A/3P BREAKER").
   e. Sample Label:

      DISTRIBUTION PANEL DP-H1
      480Y/277V
      FED FROM SWITCHBOARD "SB-1" (LOCATED IN MAIN ELEC ROOM)

4. Provide the following on a separate label, installed below the label above:

   a. Available fault current; refer to one-line diagram or panel schedules
   b. Date of fault current study; refer to one-line diagram
   c. Sample Label:

      22,000 AMPS AVAILABLE FAULT CURRENT
      DATE OF STUDY: 1 JAN 2017

C. Arc Energy Reduction Label:

1. Provide a separate engraved plastic laminate label centered at the top of each vertical section of the electrical gear indicating the following when applicable.

   a. Label: "This equipment is designed with a system listed below".
   b. Applicable Systems:

      1) Zone-selective interlocking system for selective coordination and arc energy reduction
      2) Differential relaying system for selective coordination and arc energy reduction
      3) Arc energy reducing maintenance switch
      4) Energy reducing active arc flash mitigation system

D. Adjustable-Trip Over Current Protection Label:

1. Provide a separate engraved plastic laminate label adjacent to each overcurrent projection device with adjustable trip settings. Provide label separate from load identification label.

   a. Label:

      1) Long-time delay:
      2) Long-time pickup:
      3) Short-time delay:
      4) Short-time pickup:
      5) Instantaneous:
      6) Ground fault delay:
      7) Ground fault:

b. Sample Label:

Long-time delay:	10.0
Long-time pickup:	1.0
Short-time delay:	0.15
Short-time pickup:	5.0
Instantaneous:	2.0
Ground fault delay:	0.25
Ground fault:	50.0

E. Nominal System Voltage Label:

1. Where more than one nominal voltage system exists in a building or facility, the identification of color coding used in the panelboard or equipment shall be permanently posted on the interior of the door or cover.

F. Distribution panelboards and switchboards shall have each overcurrent protection device identified with name and location of the load being served ("AHU-1 LOCATED IN PENTHOUSE 1"). Provide a separate engraved plastic laminate label adjacent to each overcurrent projection device with feeder wire size, feeder wire quantity, conductor material and distance in feet. Provide label separate from load identification label and adjustable trip settings label.

1. Sample Labels for Feeders:

4#3/0 CU & 1#6 CU GND, 125FT
4#250KCM AL & 1#6 GND CU, 125FT
2 SETS 4#400KCM CU & 1#1 GND CU, 125FT

G. Branch panelboards shall be provided with typed panel schedules upon completion of the project. Existing panelboards shall have their existing panel schedules typed, with all circuit changes, additions or deletions also typed on the panel schedules. A copy of all panel schedules for the project shall be turned over as part of the O&M Manuals. Refer to Section 26 05 00 for other requirements.

3.9 TRANSFORMER EQUIPMENT IDENTIFICATION

A. Products:

1. Nameplates and signs

B. Provide identification on the front of all transformers. The identification nameplate shall be an engraved plastic-laminated label.

C. Labeling shall include:

1. Equipment type and contract documents designation of equipment
2. Name of the upstream equipment.
3. Voltage and rating of the equipment.
4. Location of the upstream equipment if it is not located within sight.
5. Sample Label:

TRANSFORMER TR-15
480V: 208Y/120V 15KVA
FED FROM SWITCHBOARD "SB-1" (LOCATED IN ELEC 123)

END OF SECTION 26 05 53

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SECTION 26 05 73 - POWER SYSTEM STUDY

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Medium and low voltage distribution system power study.

B. Short-circuit analysis and report.

C. Selective coordination analysis and report.

D. Arc-flash hazard analysis and report.

1.2 RELATED SECTIONS

A. Section 26 05 00 - Basic Electrical Requirements

B. Section 26 11 00 - Secondary Unit Substation

C. Section 26 24 13 - Switchboards

D. Section 26 24 16 - Panelboards

E. Section 26 32 13 - Packaged Engine Generator Systems

F. Section 26 36 00 - Transfer Switch

1.3 QUALITY ASSURANCE

A. Analyses shall be performed by an agent authorized by the manufacturer of equipment specified in the related specification sections.

1.4 SUBMITTALS

A. Documentation shall bear the seal/signature of the licensed Professional Engineer who performed the analysis.

B. The input for the power system study shall be based on the contract documents, with estimated conductor lengths provided by the Electrical Contractor. IMEG will provide a preliminary Power Tools for Windows project file for information, if requested.

C. Documentation of the analyses shall be submitted in a single bound electronic (PDF or equal) format and shall accompany the shop drawing submittals for equipment provided under the related work specification sections. The submittal of these related specification sections will not be reviewed without this documentation. Submit a sample arc-flash hazard label for Owner review and approval prior to printing.

D. Power system study project model shall be submitted on electronic media for review and the Owner's operating and maintenance records.

1.5 REFERENCES

A. NFPA 70 - National Electrical Code (NEC)

B. NFPA 70E - Standard for Electrical Safety in the Workplace

C. IEEE 1584 - IEEE Guide for Performing Arc-Flash Hazard Calculations, latest version

D. ANSI Z535.4 - Products Safety Signs and Labels

1.6 SCOPE

A. Provide a power system study of the electrical system shown on the plans. The study shall include arc-fault analysis, selective coordination analysis and arc flash hazard analysis.

B. Contractor is required to provide a fully coordinated system for the emergency electrical system or emergency electrical system and the associated normal side of each transfer switch and all other locations indicated on the one line diagram. Contractor shall provide overcurrent protective devices with the appropriate models, frame sizes, trip units, etc. as required to provide a selectively coordinated system.

PART 2 - PRODUCTS

2.1 Power systems study shall be completed in Power Tools for Windows (PTW) 8.0 or later version or pre-approved equivalent program.

PART 3 - EXECUTION

3.1 SHORT-CIRCUIT ANALYSIS

A. Provide a complete short-circuit analysis from the utility service to and including the entire building distribution as shown on the drawings.

B. Analysis shall include the entire distribution system from the point of connection to the utility power source to the distribution panels and branch circuit panelboards.

C. Short-circuit analysis documentation shall be made in one-line diagram form showing the magnitude and location of each calculated fault. Fault current calculations shall be made at the main bus of each switchboard, distribution panel, and branch circuit panel. A summary of the fault currents available shall also be submitted and made available to the AHJ if requested.

3.2 SELECTIVE COORDINATION ANALYSIS

A. Provide a complete selective coordination analysis, comparing time/current curves of the protective devices to be installed to assure complete selectivity between main and downstream devices for code-required branches and branches identified on one-line drawings. Overcurrent protective devices serving the essential electrical system shall selectively coordinate for the period of time that a fault's duration extends beyond 0.01 second. Overcurrent protective devices serving the normal shall selectively coordinate for the period of time that a fault's duration extends beyond 0.01second.

B. Provide trip settings for all (selectively coordinated and non-selectively coordinated) adjustable trip over current protection devices including long time delay, long time pickup, short time delay, short time pickup, instantaneous and ground fault. Selectively coordinated branches shall be based on the selective coordination study results. Non-selective coordinated branches shall be based on the design trip ratings. Provide selective coordination between all ground fault trip settings.

C. The analysis shall include primary protective device, secondary main switchboard device(s), switchboard branch feeder devices, generator breaker, distribution panel, panelboard main devices, and branch feeder devices.

D. The coordination plots provided shall indicate graphically the coordination proposed for the system on full-size log forms and shall define the types of protective devices selected, together with proposed time dial and pickup settings required. The plots shall include titles, representative one-line diagrams, legend, complete parameters for transformer(s), and complete operating bands for circuit breaker trip devices, fuses, etc.

1. The long-time region of the coordination plots shall designate the pickups required for the circuit breakers.
2. The short-time region shall indicate the magnetizing in-rush and ASA-withstand-transformer parameter, the circuit breaker, short-time and instantaneous trip devices, fuse-manufacturing tolerance bands, significant symmetrical fault currents, etc.
3. Each primary protective device required for the transformer shall be selected so the characteristics or operating band is within the transformer parameters, which shall include a parameter equivalent to 58% of the withstand point to afford protection for secondary line-to-ground faults. The transformer damage curve shall be included for the transformer when the selected protective device is not within the associated parameters.
4. Molded case circuit breakers shall be separated from each other and the associated primary protective device by a 16% current margin for coordination and protection in the event of secondary line-to-line faults.
5. Include zone selective interlocking, differential relaying, and other selective coordination technology in the study when required by other specification sections.
6. The protective device characteristics or operating bands shall be suitably indicated to reflect the actual symmetrical fault currents sensed by the device.
7. The drawings and specifications indicate the general requirements for motors, motor-starting equipment, and medium-voltage and low-voltage equipment, but additional specific requirements of equipment furnished shall be determined in accordance with the results of the coordination study.

    a. The study shall include verification of equipment ratings and settings. The Contractor shall keep the study up-to-date with any project changes which affect the study and submit the revised study for review. A final electronic copy shall be submitted with the record drawings.

E. Provide summary table of adjustable overcurrent protective devices settings for the operating and maintenance manual.

3.3 ARC FLASH HAZARD ANALYSIS

A. The arc flash hazard analysis shall be performed according to the IEEE 1584 equations that are presented in NFPA70E.

B. The flash protection boundary and the incident energy shall be calculated at all significant locations in the electrical distribution system (switchboards, switchgear, unit substations, motor-control centers, panelboards, busway, and splitters) where work could be performed on energized parts.

C. Safe working distances shall be based on the calculated arc flash boundary considering an incident energy of 1.2 cal/cm2.

D. When appropriate, the short circuit calculations and the clearing times of the phase overcurrent devices will be retrieved from the short-circuit analysis and coordination study models. Ground overcurrent relays should not be taken into consideration when determining the clearing time when performing incident energy calculations

E. The short-circuit calculations and the corresponding incident energy calculations for multiple system scenarios must be compared, and the greatest incident energy must be uniquely reported for each equipment location. Calculations must be performed to represent the maximum and minimum contributions of fault current magnitude for all normal and emergency operating conditions. The minimum calculation will assume that the utility contribution is at a minimum and will assume a minimum motor contribution (all motors off). Conversely, the maximum calculation will assume a maximum contribution from the utility and will assume the maximum amount of motors to be operating. Calculations shall take into consideration the parallel operation of synchronous generators with the electric utility, where applicable.

F. The incident energy calculations must consider the accumulation of energy over time when performing arc flash calculations on buses with multiple sources. Iterative calculations must take into account the changing current contributions, as the sources are interrupted or decremented with time. Fault contribution from motors and generators should be decremented as follows:

1. Fault contribution from induction motors should not be considered beyond 3 to 5 cycles.
2. Fault contribution from synchronous motors and generators should be decayed to match the actual decrement of each as closely as possible (e.g., contributions from permanent magnet generators will typically decay from 10 per unit to 3 per unit after 10 cycles).

G. For each equipment location with a separately enclosed main device (where there is adequate separation between the line side terminals of the main protective device and the work location), calculations for incident energy and flash protection boundary shall include both the line and load side of the main breaker.

H. Include Arc Energy Reduction (AER) analysis in the study when required by other specification sections.

I. When performing incident energy calculations on the line side of a main breaker (as required per the above), the line side and load side contributions must be included in the fault calculation.

J. Miscoordination should be checked among all devices within the branch containing the immediate protective device upstream of the calculation location, and the calculation should utilize the fastest device to compute the incident energy for the corresponding location.

K. Where it is not physically possible to move outside the flash protection boundary in less than 2 seconds during an arc flash event, a maximum clearing time based on the specific location shall be utilized.

L. Create and install NFPA 70E compliant labels describing the arc flash hazard level at all switchboards, panelboards, and other locations in the electrical distribution system where work could be performed on energized parts.

M. Labels shall be vinyl or laminated, with a self-adhesive backing, conform with ANSI Z535.4 Products Safety Signs and Labels standard, and include the following:

1. Arc flash boundary
2. Available incident energy calculated in the analysis and the corresponding working distance, or the arc flash personal protective equipment (PPE category) for the equipment, but not both.

N. A list of all hazard categories and the corresponding PPE requirements shall be posted in the main electric room, engineering office, or other location. The list shall be plastic laminate or typewritten and housed in a plastic frame.

3.4 ADJUSTMENTS

A. Manufacturer's authorized representative or Contractor shall set all adjustable protective devices to values indicated in the approved coordination study. Apply settings prior to placing equipment into operation. When the scope of work or execution includes remodel or phases construction, the contractor shall adjust applicable settings as required prior to each system component placed in operation.

B. Wherever the arc flash incident energy exceeds Arc Flash Category 2 (i.e. greater than 8 cal/cm^2), provide options for adjusting breaker trip times, if possible, to reduce energies to Category 2 or below.

3.5 TRAINING

A. Provide four hours of Owner training to explain the implications of arc-flash requirements and work permit procedure.

END OF SECTION 26 05 73

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SECTION 26 08 01 - COMMISSIONING OF ELECTRICAL

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Description

B. Responsibilities

C. Related Work

D. Test Equipment

1.2 DESCRIPTION

A. The purpose of this section is to specify Division 26 responsibilities in the commissioning process.

B. The systems to be commissioned are the electrical lighting systems listed in IECC 2012 Section C408 applicable to the project.

1. Lighting and Lighting Controls

1.3 RESPONSIBILITIES

A. Commissioning requires the participation of the Division 26 Contractor to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Section 01 91 01. Division 26 Contractor shall be familiar with all parts of Section 01 91 01 and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

B. Refer to Section 01 91 01 for more information.

1.4 RELATED WORK

A. Specific commissioning requirements are given in the following sections of these specifications. All the following sections apply to the Work of this section.

1. Section 01 78 23 - Operations and Maintenance
2. Section 01 79 00 - Demonstration and Training
3. Section 01 91 01 - Commissioning
4. Section 22 08 01 - Commissioning of Plumbing
5. Section 23 08 01 - Commissioning of HVAC

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

A. The Contractor shall provide all test equipment necessary to fulfill the testing requirements of this Division. This equipment includes, but is not limited to, the following:

1. Light meter.
2. Digital multimeter capable of measuring voltage (AC/DC), current, and resistance.

B. All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the related specifications. All equipment shall be calibrated according to the manufacturer's recommended intervals and when dropped or damaged. Calibration tags shall be affixed or certificates readily available.

C. Refer to Section 01 91 01 for additional Division 26 requirements.

PART 3 - EXECUTION

A. Refer to Section 01 91 01 for additional information.

END OF SECTION 26 08 01

SECTION 26 09 13 - POWER MONITORING AND CONTROL SYSTEM

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Power monitoring and control system is defined to include, but is not limited to, remote devices for monitoring communication interface hardware, inter-communications wiring, network software, printer, and personal computer workstations.

B. The system shall utilize Ethernet as the high-speed backbone network that supports direct connection of personal computer workstations anywhere on the network. Each personal computer workstation shall have equal access to information provided by the power monitoring devices for data display, data logging, alarming, event recording, and other monitoring operations.

1.2 RELATED SECTIONS AND WORK

A. Refer to the One-Line Diagram for rating, location and configuration.

B. Section 26 24 13 - Switchboards

1.3 QUALITY ASSURANCE

A. Manufacturer: Company with three (3) years of experience in power measurements and controls.

1.4 REFERENCES

A. ANSI C12 - Code for Electrical Metering

B. ANSI C57.13 - Requirements for Instrument Transformers

1.5 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 26 05 00.

B. Provide product data showing the type, size, rating, catalog number, manufacturer's names, and/or data sheets for all items to ensure compliance with these specifications. Submit operation and programming manual.

C. Submit shop drawings of the complete layout of the entire system, showing wiring and all equipment.

1.6 REGULATORY REQUIREMENTS

A. System: UL listed.

1.7 SYSTEM DESCRIPTION

A. The power monitoring and controls (PMCS) shall consist of electronic power monitoring devices as designated on the project drawings and described herein. The system shall be capable of monitoring, displaying, logging, and communicating the true RMS measurements in this specification as a minimum level of performance. The system shall be designed so the maximum response time from an event or reading to displaying shall be 60 seconds.

B. Each personal computer workstation connected to the network shall have web-based access to information provided by the PMCS.

C. Minimum accuracy of readings shall be:

1. Frequency ± 0.01 Hz.
2. Current and voltage ± 0.5% of reading.
3. Energy ± 1% of reading.

1.8 PROJECT RECORD DOCUMENTS

A. Provide installation and maintenance manuals under provisions of Section 26 05 00. Include name, address and telephone number of service location within 100 miles of project.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Square D - POWERLOGIC and ION Enterprise

B. Eaton Power Xpert

C. ABB

D. Siemens

2.2 POWER MONITORING NETWORK

A. The PMCS shall be connected by means of an Ethernet high-speed backbone. The high-speed network shall consist of gateways, switches, patch cords, backbone cabling, and any required equipment.

B. Ethernet gateways or communications cards shall be provided and installed by the PMCS vendor as required. Ethernet network connections shall be established using industry standard Ethernet protocol, such as TCP/IP.

C. Patch Cords: Cat 6; color to be determined by the Owner.

D. Backbone Media:

1. Distances not exceeding 295 feet: Provide Cat 6 cable in 3/4" conduit. Cable color selection by Owner.
2. Distances equal to or exceeding 295 feet: Provide six-strand multimode fiber optics installed in 1-1/4" conduit, and interface hardware.

E. Wireless Ethernet and interface hardware shall be provided and installed by the PMCS vendor in Electrical Code classified areas.

F. Ethernet Gateways:

1. The Ethernet gateways shall be modular in design to allow for easy future expansion or modification of the system. Ethernet gateway shall support Ethernet UTP (10/100 Mbps). Each Ethernet gateway shall provide a web-based interface for device configuration, diagnostics, and access for users to power monitoring information from any location on a local area network (LAN) or wide area network (WAN).

G. The PMCS shall be connected by mean of the facilities Ethernet backbone. Provide Ethernet gateway or communication cards as required to connect system to network jacks installed as part of the facility's Ethernet network. Network connections shall be established using industry standard Ethernet protocol, such as TCP/IP. All components shall work with facility's Ethernet switches, router, and hub technology.

2.3 INTERFACE TO EXTERNAL SYSTEMS

A. The high-speed network utilized by the PMCS system shall permit easy interface with the Facilities Management and Control System (FMCS).

B. Data located in the power monitoring devices and PLC registers and associated inputs/outputs shall be made available to the FMCS vendor via meters. Hardware and software required by the FMCS to retrieve this data from the PMCS data highway shall be the responsibility of the FMCS vendor.

2.4 PERSONAL COMPUTER WORKSTATION

A. Provide the web access software for 3personal computer workstations.

B. Provide the software to allow printing from an Owner-furnished network printer.

2.5 PMCS APPLICATION SOFTWARE

A. The PMCS manufacturer shall supply application software that provides the operator access to all meter data, systems reports, breaker/contactor/switch status communication alarms, and logged data.

B. All software shall be configured by the vendor and delivered ready to use. The configuration shall include preparation of all required graphics, displays, and interactive one-line diagrams. When additional devices are added in the future, the user shall be able to add the communication address and device type, and the software shall automatically display all data from the device in a format identical to that used by existing devices of the same type.

C. In addition to the PMCS application software programs, each PC shall permit the use of other Windows-based programs as desired by the user.

D. Application software shall be supplied to support system configuration, monitoring of the devices, data logging, alarming, and other operations associated with the PMCS. The software provided shall include the following software option(s):

1. System Monitoring (multiple devices at a time):

a. Application designed to monitor the entire system of power monitoring devices in the background for alarms, events, and data logging, allowing the operator to perform other tasks with the workstation.
b. Display information from the PMCS in a variety of standard formats, including real time data and trend displays, historical reports, graphical displays with real-time data updates, support of .pdf, .doc, .txt, .html, .htm, .xls and .ppt file formats.
c. Log PMCS data to printer and hard disk at user-specified intervals and provide exporting functions to allow usage of the logged data by other software products.

d. Color-coded alarms for digital quantities and analog quantities, each with user-selectable indication including visual, audible, and/or required acknowledgment. Additionally, multi-level alarms shall be supported for analog quantities.
e. Events shall be recorded in an Event Log file with a minimum storage capacity of 1000 events, the date/time of the event, and a descriptive text.
f. Report the status of metering devices inputs and outputs, status I/O associated with programmable logic controllers, etc.
g. Password protected resets accumulated real, accumulated reactive energy, energy management alarms, minimum and maximums, and other circuit quantities associated with the power monitoring devices.
h. Graphical waveform displays for the voltages, phase currents, and residual current monitored by metering devices.
i. Include harmonic information in the graphic waveform displays for metering devices including total harmonic distortion (THD), RMS magnitudes, peak values, crest factors (CF), magnitudes of the individual harmonics, telephone interference fact (TIF), etc.

2.6 PMCS APPLICATION REPORTS

A. Capable of custom report creation. Standard report templates shall include historical tables and trends, energy profile, cost allocation, power factor and alarm analysis.

B. Graphical views of historical trending shall support both pan and zoom. All standard metering parameters shall be logged, including minimum, maximum, and average.

C. Reports shall be generated on demand or as a scheduled task to run automatically at specified intervals.

D. Shall have the ability to view data from different devices on the same trend plot simultaneously.

E. Shall have the ability to filter end user access to reports based on user name/login.

2.7 SOFTWARE SERVICE AGREEMENT

A. The electrical equipment manufacturer shall include a three (3) year Software Service Agreement, which provides the customer with software upgrades for the software specified above as they are available.

2.8 POWER MONITORING DEVICES INSTALLATION

A. All metering devices,shall be installed by the equipment manufacturer for all circuits as indicated by the project drawings.

B. All control power, CT, PT, and data communications wire shall be factory wired and harnessed within the equipment enclosure. Where external circuit connections are required, terminal blocks shall be provided, and the manufacturer's drawings must clearly identify the interconnection requirements, including wire type to be used.

C. Provide control transformers, current transformers, and fused potential transformers sized as required.

2.9 POWER MONITORING DEVICE CHARACTERISTICS

A. DEM; Energy Meter:

1. The following instantaneous readings shall be monitored, displayed, and communicated by the energy meter:

a. Frequency

b. Current, per phase RMS, 3-phase average RMS, apparent RMS, peak demand
c. Voltage, phase-to-phase and phase-to-neutral
d. Power factor, per phase and 3-phase total
e. Real power (kW), 3-phase total, peak demand, cumulative (kWH)
f. Reactive power (kVAR), 3-phase total

2. The current and voltage signals shall be digitally sampled at a rate high enough to provide true-RMS sensing. All setup parameters required by the energy meter shall be stored in nonvolatile memory and retained in the event of a control power interruption. The meter shall maintain in nonvolatile memory maximum and minimum values for each of the instantaneous values reported, as well as the time and date of the highest peak for all peak demand readings.
3. The energy meter shall be equipped with a display to provide local access to all metered quantities where indicated on plans.
4. Reset of the following electrical parameters shall also be allowed from the front of the meter:

a. Peak demand current
b. Peak demand power
c. Energy (MWH)
d. Reactive energy (MVARH)

5. Manufacturers:

a. Square D Power Logic PM5000
b. Eaton
c. Siemens PAC3100
d. ABB M4M Series

B. EEM; External Energy Meter:

1. External energy meters shall have the same functions as the energy meter specified above. The external energy meters shall have communication capabilities to send information on the PMCS network.
2. Manufacturers:

a. Square D Power Logic EM4900
b. Eaton
c. Siemens PAC4200
d. ABB EQ Series

C. DPM; Power Meter:

1. The following instantaneous readings shall be monitored, displayed, and communicated by the power meter:

a. Frequency, monthly maximum and minimum
b. Current, per phase RMS, 3-phase average RMS, apparent RMS, peak demand (15-minute sliding window)
c. Voltage, phase-to-phase and phase-to-neutral
d. Power factor, per phase and 3-phase total
e. Real power (kW), 3-phase total, peak demand, cumulative (kWH)
f. Reactive power (kVAR), 3-phase total
g. Total harmonic distortion (current and voltage)

2. The current and voltage signals shall be digitally sampled at a rate high enough to provide true-RMS sensing through the 31st harmonic. All setup parameters required by the power meter shall be stored in nonvolatile memory and retained in the event of a control power interruption. The meter shall maintain, in nonvolatile memory, maximum and minimum values for each of the instantaneous values reported, as well as the time and date of the highest peak for all peak demand readings.
3. The power meter shall be equipped with a display to provide local access to all metered quantities.

4. Reset of the following electrical parameters shall also be allowed from the front of the display or energy meter:

    a. Peak demand current
    b. Peak demand power
    c. Energy (MWH)
    d. Reactive energy (MVARH)

5. The power meter shall have one (1) digital input and one (1) digital solid state output/KY pulse output.
6. The power meter shall be provided with a six (6) digital input and two (2) digital output (relay) output accessory card.
7. Manufacturers:

    a. Square D Power Logic PM8240
    b. Eaton
    c. Siemens PAC4200
    d. ABB M4M Series

D. PQM; Power Quality Meter:

1. The following instantaneous readings shall be monitored, displayed, and communicated by the power quality meter:

    a. Frequency, monthly maximum and minimum
    b. Current, per phase RMS, 3-phase average RMS, apparent RMS, peak demand (15-minute sliding window)
    c. Voltage, phase-to-phase and phase-to-neutral
    d. Power factor, per phase and 3-phase total
    e. Real power (kW), 3-phase total, peak demand, cumulative (kWH)
    f. Reactive power (kVAR), 3-phase total
    g. Total harmonic distortion (current and voltage)
    h. Power analysis values

2. The current and voltage signals shall be digitally sampled at a rate high enough to provide true-RMS sensing through the 85th harmonic. All setup parameters required by the power quality meter shall be stored in nonvolatile memory and retained in the event of a control power interruption. The meter shall maintain, in nonvolatile memory, maximum and minimum values for each of the instantaneous values reported, as well as the time and date of the highest peak for all peak demand readings.
3. The power quality meter shall be equipped with a display to provide local access to all metered quantities.
4. Reset of the following electrical parameters shall also be allowed from the front of the meter:

    a. Peak demand current
    b. Peak demand power
    c. Energy (MWH)
    d. Reactive energy (MVARH)

5. The power meter shall have four (4) digital inputs and one (1) digital solid state output/KY pulse output.
6. The power quality meter shall be provided with a four (4) digital input and four (4) analog (4-20mA) output accessory card.
7. Manufacturers:

    a. Square D Power Logic CM3350
    b. Eaton IQ ANALYZER 6000 XPERT Series
    c. Siemens 9510
    d. ABB M4M Series

E. Electronic Trip Units:

1. Electronic trip units shall be provided as designated on the project drawings.
2. They shall provide the following breaker/trip unit information to the PMCS network:

   a. Breaker sensor rating
   b. Rating plug
   c. Date/time of last trip
   d. Type of last trip (overload, short circuit, ground fault)
   e. Magnitude of phase and ground fault at time of last trip
   f. Number of overload trips
   g. Number of short circuit trips
   h. Number of ground fault trips

3. The electronic trip units designated P in the one-line diagram shall provide equivalent information to the digital power meter specified above. The electronic trip units designated H in the one-line diagram shall provide equivalent information to the power quality meter specified above.

F. Transformer Temperature Monitors:

1. The transformer temperature monitors shall provide the following information to the PMCS network:

   a. Coil temperatures - Phases A, B and C
   b. Hottest coil temperature
   c. Fan relay status
   d. Alarm relay status
   e. Emergency over-temperature relay status
   f. Setpoints for fans, alarm, and over-temperature relays

2. Transformer temperature monitors shall be provided for each dry-type and cast resin transformer shown on the project drawings.

G. Electronic Motor Protective Devices:

1. Electronic motor protective devices as noted on the project drawings shall be able to model (learn) the thermal loading of the motor and cooldown characteristics to maximize protection during continuous and load cycling operation. Each motor circuit noted on the drawings shall be equipped with a PMCS interface.
2. Historical operating information, such as running hours since last commissioning, number of starts/trips since last commissioning, number of overload trips/ground fault trips, and similar data, shall be displayed on the front of the device and be available via data communications to programmable logic controllers and personal computer workstations throughout the PMCS network for control, alarming, etc.
3. The motor protective devices shall provide fault diagnosis data such as pre-trip motor and ground fault currents, unbalance ratio, and maximum stator RTD temperature.

2.10 SYSTEM DISPLAY UNITS

A. System display units shall be provided to display the data available from selected electronic trip units connected on the individual data transfer network.

B. The system display unit shall utilize a 4 line by 20 character, high contrast display with backlighting. The level of backlighting as well as the contrast shall be adjustable.

C. The system display shall be equipped with a screen saver feature to extend the life of the display.

D. Data shall be displayed in a logically organized manner, complete with the proper scaling and units.

E. The system display unit shall allow for easy operation by providing a keypad with large keys for operator selections. The keys shall have a raised perimeter and tactile feedback to provide a positive response, even with gloved-hand operation.

F. The keys shall be clearly marked to indicate the function and separated into meaningful groups, with display prompting to assist the user in operation.

G. Each system display unit shall be configured by the manufacturer with all necessary data. It shall be possible to change the configuration for each system display unit using the keypad provided on each display. Access to configuration functions shall be password protected to prevent unauthorized or accidental modification.

H. The system display unit shall permit the reset of the stored min-max values in the power monitoring devices. It shall also permit the reset of the accumulated energy values and the time and date stamps stored in the metering devices. These resets shall be limited to authorized persons by means of password protection.

2.11 AUTOMATIC CONTROL

A. Programmable logic controllers (PLCs) that communicate with the meter devices, electronic trip units, transformer temperature monitors, motor protective devices, and other compatible devices for performing control operations shall be provided.

B. Each PLC shall include ladder programs that will direct the automatic control operations as specified.

C. Processor, input, output, and network interface cards shall be provided as necessary to implement the sensing and automatic control operations.

D. Data pertaining to the automatic control system shall be transmitted via the PMCS network to the remote personal computers.

E. At a minimum, the application software at the personal computer shall provide the following:

1. Interactive color-graphics, one-line of automatic control system (breaker status, relays status, etc.).
2. All automatic control operations (open/close breaker, relay operation, etc.) shall be date/time stamped and recorded in an event log.
3. Setup and display alarm conditions for automatic control operations shall be possible, with each alarm condition entered in the event log.
4. Manual operator intervention via the keyboard or interactive one-line graphics shall be provided such that any point in the process may be controlled. Manual intervention shall be password protected to prevent inadvertent or unauthorized override of the control scheme.
5. Protective relaying functions, anti-paralleling interlocks, or load limits shall not be defeatable.

PART 3 - EXECUTION

3.1 INSTALLATION

A. PMCS components, including system display units, metering devices, shall be installed by the manufacturer, and wired and tested in the equipment as indicated on the drawings. All control power, CT, PT, and data communications wire shall be factory wired and harnessed within the equipment enclosure.

B. Where external circuit connections are required, terminal blocks shall be provided and the manufacturer's drawings must clearly identify the interconnection requirements, including wire type to be used.

C. All wiring required to externally connect equipment lineups shall be installed by the Electrical Contractor.

3.2 COMMISSIONING

A. Power Monitoring and Control Systems shall be commissioned by Commissioning Agent.

B. The contractor shall provide provisions to administrate and support the commissioning process. Refer to the commissioning plan specifications for additional requirements.

C. Witness Testing: Provide written notification a minimum of two weeks prior to commencing any final system commissioning. The Architect/Engineer, owner, and Authority Having Jurisdiction shall provide witness testing of the commissioning process.

3.3 STARTUP AND TRAINING

A. Onsite startup and training of the PMCS shall be included in the project bid. Startup shall include a complete working demonstration of the PMCS, with simulation of possible operating conditions that may be encountered.

B. Training shall include any documentation and hands-on exercises necessary to enable electrical operations personnel to assume full operating responsibility for the PMCS after completion of the training period.

C. The project bid shall include two (2) days startup assistance and three (3) days training to include two training sessions, with the second training session being two (2) months after occupancy.

D. The power monitoring manufacturer shall provide a full-time telephone technical help center for customers.

END OF SECTION 26 09 13

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SECTION 26 09 16 - ELECTRICAL CONTROLS AND RELAYS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Relays and Timers

B. Pushbutton Operators

C. Control Power Cabinets

PART 2 - PRODUCTS

2.1 CONTROL RELAYS

A. Mount relays in separate NEMA 1 enclosure or in control terminal cabinet.

B. R-1; Power Relay:

1. Visible contacts, coil burden less than 10 V.A. 120volt A.C. coil, 600-volt A.C. contacts, 2 normally open contacts, 10-amp continuous contacts electrically held.
2. Manufacturers:

   a. Square D Type C Class 8501 CO
   b. Eaton
   c. ABB
   d. Siemens

C. R-1; General Purpose Relay:

1. 120volt continuous duty coil, 1 N.O. and 1 N.C. contacts, electrically held, 12-amp, 240 volt rated contacts. Provide compatible plug-in base socket.
2. Manufacturers:

   a. Square D Class 8501 Type K
   b. Eaton
   c. ABB
   d. Siemens

2.2 TIME RELAYS

A. R-1; Time relays: shall be rated and shall be electric type incorporating mode of on delay off delay interval one shot repeat cycle off impulse. Time period shall be adjustable.

B. Time relays shall be mounted in NEMA 1 enclosures in control terminal cabinet.

C. Manufacturers:

1. Square D Class 9050 Type RE7
2. Eaton
3. ABB
4. Siemens

2.3 CONTROL POWER CABINET (CPC)

A. Provide a 12"x8"x4" screw cover NEMA 1 enclosure, single pole specification grade 20-amp switch in a single gang box, fuse block, fuses and equipment for interface of temperature control system. Mount above accessible ceiling.

B. Manufacturers:

1. Enclosure - Hoffman A-SE12X8X4, Weigmann, Hammond Manufacturing
2. Fuseholders - Bussman NDNLDF-WH, Mersen, Littelfuse
3. Neutral Block - Bussman NDNV4-WH, Mersen, Littelfuse

2.4 CONTROL POWER CABINET (CPC)

A. 500 VA power supply with 5 isolated 24 VAC 100 VA Class II secondaries. 480/277/240/120 VAC primary. Secondary circuit breakers, manual switch and indicator light. 12"x12"x6" screw cover NEMA 1 steel enclosure. Equipment for interface of temperature control system. Mount above accessible ceiling.

1. Manufacturers:

a. Functional Devices, Inc. PSH500A.

2.5 EMERGENCY POWER OFF (EPO)

A. Mushroom head, (1) N.O. (1) N.C. contacts, 120 volt, turn to release, provide engraved nameplate. Provide guarded enclosure cover to protect from accidental operation. Parallel wire all EPO in suite when applicable.

1. Provide engraved nameplate: EMERGENCY OFF.

2. Manufacturers:

a. Square D 9001 XB5AS8445- KYG1Y
b. Eaton
c. ABB
d. Siemens 52PA2W2A

2.6 LAMP ANNUNCIATOR (FA-LA)

A. Four indicators across and one indicator down. Surface mount, 125 volt. Supply with lamp test, lamp reset, and acknowledge buttons. Provide with 1/4" character height.

2.7 MOMENTARY PUSHBUTTON (PB)

A. Non-illuminated, round 1-3/8" diameter mushroom button, (1) normally open, (1) normally closed contact. Contacts rated 10 amps continuous. Provide 2-1/4" square engraved nameplate with white background and black letters.

1. Manufacturers:

a. Square D Class 9001- SKR4RH13 button (2) KA1 contacts - KN100WP nameplate
b. (2) KA1 contacts - KN100WP nameplate

PART 3 - EXECUTION

3.1 INSTALLATION

A. Coordinate with Mechanical Division 23 in connection of control conduit into control terminal cabinet.

B. Install line voltage thermostats for single phase motors. Provided by Division 21/22/23.

C. Provide remote control connection to remote devices.

END OF SECTION 26 09 16

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SECTION 26 09 33 - LIGHTING CONTROL SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Line and low voltage standalone lighting controls

B. Automatic load control relay (ALCR20)

C. Distributed lighting control

1.2 RELATED SECTIONS

A. The lighting system design includes a combination of luminaire sources, lighting control components, programming sequences, and supplementary components for building and energy code compliance. The design uses performance-based specifications for portions of the lighting system to account for the limitation of comparable product solutions available by competitive manufacturers. The Contractor shall reference related specification sections, plans, schedules, and details prior to submitting pricing, submittals, and installation. The Contractor shall coordinate system component compatibility among various manufacturers and suppliers for a turnkey lighting system. Referenced sections include, but are not limited to, the following:

1. 26 51 19 LED Lighting
2. Electrical Drawings: Plans, luminaire schedules, lighting control sequence of operations, diagrams, and details.

1.3 RELATED WORK

A. Section 01 91 00 - Commissioning

1.4 QUALITY ASSURANCE

A. Manufacturers shall be regularly engaged in the manufacture of lighting control equipment and ancillary equipment, of types and capacities required, whose products have been in satisfactory use in similar service for not less than five (5) years.

B. All components and assemblies are to be factory pre-tested prior to delivery and installation.

C. Comply with Electrical Code as applicable to electrical wiring work.

D. Comply with applicable portions of NEMA standards pertaining to types of electrical equipment and enclosures.

E. Panels and accessory devices are to be UL listed under UL 916 Energy Management Equipment. Panels and accessories used for control of life safety and critical branch circuits shall be listed under UL 924 Emergency Lighting and Power Equipment.

F. All assemblies are to be in compliance with FCC emissions standards specified in Part 15 Subpart J for Class A applications.

1.5 REFERENCES

A. FCC Rules and Regulations, Part 15, Subpart J - Radio Frequency Interference

B. FS W S 896 Switch, Toggle

C. International Energy Conservation Code (IECC)

D. NEMA WD 1 - General Color Requirements for Wiring Devices

E. NEMA WD 7 - Occupancy Motion Sensors

F. NFPA 70 - National Electrical Code (NEC)

G. UL Standard 916 Energy Management Equipment

H. UL 924 - Emergency Lighting and Power Equipment

I. UL 1472 - Solid-State Dimming Controls

1.6 SUBMITTALS

A. Submit product data under provisions of Section 26 05 00.

B. Submit a comprehensive package including devices, hardware, software, product specification, finishes, dimensions, installation instructions, warranty, system software requirements, and roles and responsibilities of all persons and groups involved in installation, execution, and commissioning.

C. Provide floor plan showing location, orientation, and coverage area of each control device, sensor, and controller/interface. For areas requiring multiple sensor devices for appropriate coverage, submit specific manufacturer-approved sensor layout as an overlay directly on the project drawings, either in print or approved electronic form.

D. Submit a list of devices and equipment that will be installed for each sequence of operation.

E. Submit project specific control wiring diagrams showing all equipment, line voltage, and control wiring requirements for all components including, but not limited to, dimmers, relays, low voltage switches, occupancy sensors, control stations, [dimmer panels, relay panels,] and communication interfaces and programming instructions for each sequence of operation. Include network cable specification and end-of-line termination details, if required.

F. Project specific network riser diagram including floor and building level details. Illustrate points of connection to integrated systems. Coordinate integration with mechanical and/or other trades.

G. Verify acceptance of communications connection to building automation system. Submit BACnet IP parameters.

1.7 EXTRA STOCK

A. Provide extra stock under provisions of Section 26 05 00.

B. Sensors, Controls, Power Supplies, and Relays: Five (5) percent of quantity installed. Minimum of two (2) of each configuration and type.

C. Relays and Dimmer Modules: Five (5) percent of quantity installed. Minimum of two (2) of each size and type.

D. Control Stations: One (1) of each configuration and type, except for LCD touch screens requiring factory setup prior to installation.

1.8 PROJECT RECORD DOCUMENTS

A. Submit project record documents under provisions of Section 26 05 00.

B. Accurately record location of all controls and devices. Include description of switching sequences and circuiting arrangements.

1.9 OPERATION AND MAINTENANCE DATA

A. Submit emergency, operation, and maintenance data under provisions of Section 26 05 00. Data shall also include the following:

1. Schedule for routine maintenance, inspection, and calibration of all lighting control devices and system components. Recommended schedule for inspection and recalibration of sensors.
2. Complete narrative describing intended operation and sequence for each control scenario and system component, updated to reflect all changes resulting from commissioning of systems. Narrative shall indicate recommended settings for devices where applicable.
3. Replacement part numbers for all system components.

B. Identify installed location and labeling for each luminaire controlled by automated lighting controls.

C. Submit software operating and maintenance manuals, program software backup on compact disc or compatible media with data files, device address list, and a printout of software application and graphic screens, where applicable.

1.10 SYSTEM DESCRIPTION

A. Performance Statement: This specification section and the accompanying lighting design documents describe the minimum material quality, required features, and operational requirements of the lighting control system (LCS). These documents do not convey every wire that must be installed and every equipment connection that must be made. Based on the performance required of the system, as presented in these documents, the Contractor and system manufacturer/vendor are solely responsible for determining all equipment, wiring, and programming required for a complete and operational system.

B. Provide an integrated lighting controls system consisting of panels, power supplies, controllers, sensors, relays, switches, devices, wiring, etc. necessary to perform the Lighting Control Sequence of Operation as defined on the plans and specifications. Contractor is responsible for confirming that all components and luminaires interoperate as a single system.

1. Sequence of Operation: Describes the required operation and performance for lighting control in each space. Sequences of operation are indicated on the drawings.
2. Drawings: The drawings include sequences of operation, locations of control interface devices, sensors, and control zones. Wiring and additional equipment to make a complete and functioning system has not been shown, but shall be submitted with the shop drawings.

C. The following control types and features are acceptable. Acceptable control locations are shown on the drawings.

1. Line Voltage Control: Control equipment consists of traditional line voltage wiring devices and equipment such as switches, dimmers and combination occupancy/vacancy sensor switches, etc.
2. Distributed Control: Control equipment is in the space/zone being controlled; not reliant on centralized controllers.

   a. All locations shall have the ability to be networked for remote control and monitoring.

3. Centralized Control: Control equipment is in a central location serving multiple spaces/zones and provides time-based schedule and remote control.

   a. The lighting control system (LCS) shall be networked with BACnet IP capabilities.

1.11 COMMISSIONING

A. Commissioning of a system or systems specified in this section is part of the construction process. Documentation and testing of these systems, as well as training of the Owner's operation and maintenance personnel, is required in cooperation with the Owner's Representative and the Commissioning Agent. Project closeout is dependent on successful completion of all commissioning procedures, documentation, and issue closure. Refer to Division 1 for detailed commissioning requirements.

B. The Contractor shall notify the Commissioning Agent, Architect/Engineer and Owner's Representative ten (10) working days prior to scheduled commissioning date.

C. The commissioning process requires meeting attendance. Refer to Division 1 for meeting requirements.

D. The system shall be functionally tested by a factory-authorized engineer and comply with the Sequence of Operation. All loads shall be tested live for continuity and freedom from defects, and all control wiring shall be tested for continuity and connections prior to energizing the system.

1.12 WARRANTY

A. Manufacturer shall warrant products under normal use and service to be free from defects in materials and workmanship for a period of two (2) years from date of commissioning.

B. Occupancy, vacancy, daylight sensors and controls shall have a five (5) year warranty from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 LIGHTING CONTROLS

A. All items of material having a similar function (e.g., switches, dimmers, sensors, contactors, relays, etc.) shall be of the same manufacturer, unless specifically stated otherwise on drawings or elsewhere in the specifications. Lighting control switches, systems, and components shall be listed.

B. Color of lighting controls and sensors shall match the receptacle wiring devices specified in the space.

C. The functions described in the lighting sequence of operation shall dictate the actual lighting control device required to accomplish the functions described for the space.

2.2 LIGHTING CONTROL STATION

A. SW; The lighting control station shall contain the controls required by the lighting sequence of operation in a common coverplate. The controls may consist of switches, dimmers, occupancy sensors, pushbuttons, etc.

1. In spaces where the wall control station is shown in multiple locations, the sequence of operation shall be the same at all locations, unless noted otherwise.
2. The controls supplier shall prepare control station shop drawings showing arrangement of controls, dimensioned elevations, wiring diagram, and recommended backboxes. The shop drawing submittal should be identified with the lighting sequence that the station provides. Submit data sheets on the switches, dimmers, sensors, buttons, etc. contained in the control station.

2.3 DEVICE COLOR

A. All switch, lighting controls, and coverplate colors shall be the same as wiring devices, unless indicated otherwise.

2.4 COVERPLATES

A. All switches and lighting controls shall be complete with coverplates that match material and color of the wiring device coverplates in the space.

B. Where several devices are ganged together, the coverplate shall be of the ganged style for the number of devices used.

C. Install nameplate identification as indicated in Section 26 05 53.

D. Plate-securing screws shall be metal with head color matching the wall plate finish.

2.5 WALL SWITCHES

A. Refer to Electrical Symbols List for device type.

B. SW-1P; Single Pole Switch:

1. Single throw, 120/277-volt, 20-amp maintained contact. Toggle handle, side and back wired.
2. Manufacturers:

   a. Hubbell HBL1221
   b. Leviton 1221-2
   c. Pass & Seymour PS20AC1
   d. Cooper AH1221

3. Single throw, 120/277-volt, 20-amp maintained contact. Rocker handle, side and back wired.
4. Manufacturers:

   a. Hubbell DS120
   b. Leviton 5621
   c. Pass & Seymour 2621
   d. Cooper 7601.

C. SW-1P-ADJ; Local Timer Switch:

1. User adjustable timeout, 120/277-volt, 800/1200 watt rating. No minimum load requirement. Flashes lights one minute before timeout.
2. Manufacturers:

   a. Watt Stopper TS-400
   b. Hubbell Automation TD200

D. SW-1P-EM; Emergency Single Pole Switch:

1. Single throw, 120/277-volt, 20-amp maintained contact. Red handle, side and back wired. Switch shall have with illuminated handle that is illuminated when load is off.
2. Manufacturers:

   a. HBL1221R
   b. Leviton 1221-2R
   c. Pass & Seymour PS20AC1-RED
   d. Cooper AH1221RD

3. Manufacturers:

   a. Pass & Seymour 2625RED.

E. SW-1P-K; Key Lock Single Pole Switch:

1. Single throw, 120/277-volt, 20-amp maintained contact. Side and back wired. Provide key to Owner.
2. Manufacturers:

   a. Hubbell HBL1221L
   b. Leviton 1221-2L
   c. Pass & Seymour PS20AC1-L
   d. Cooper AH1221L

F. SW-1P-LH; Lighted Handle Single Pole Switch:

1. 120 volt maintained contact. Toggle handle. Light on when contact open (switch off). Side and back wired.
2. Manufacturers:

   a. Hubbell HBL1221ILC
   b. Leviton 1221-LHC
   c. Pass & Seymour PS20AC1-CSL
   d. Cooper 2221LTW

G. SW-1P-M; Momentary Contact Single Pole Switch:

1. 120/277-volt, 20 amp. Three position, two circuit. Center off toggle spring return handle.
2. Manufacturers:

   a. Hubbell HBL1557
   b. Leviton 1257
   c. Pass & Seymour 1251
   d. Cooper 1995

H. SW-1P-PL; Red Pilot Light Single Pole Switch:

1. 120 volt maintained contact. Toggle handle. Pilot light on when contact closed (switch on). Side and back wired.
2. Manufacturers:

   a. Hubbell HBL1221PL
   b. Leviton 1221-PLR
   c. Pass & Seymour PS20AC1-RPL
   d. Cooper AH1221PL

I. SW-1P-WP; Weatherproof Single Pole Switch:

1. Single throw, 120/277-volt, 20-amp maintained contact. Toggle handle, side and back wired. Provide with weatherproof coverplate.
2. Manufacturers:

   a. Hubbell1221/HBL1795
   b. Leviton 1221-2
   c. Taymac MM180
   d. Pass & Seymour PS20AC1/CA1-GL
   e. Cooper 2221.

J. SW-2P; Two Pole Switch:

1. Single throw, 120/277-volt, 20-amp maintained contact. Toggle handle, side and back wired.
2. Manufacturers:

   a. Hubbell HBL 1222
   b. Leviton 1222-2
   c. Pass & Seymour PS20AC2
   d. Cooper 2222.

3. Single throw, 120/277-volt, 20-amp maintained contact. Rocker handle, side and back wired.
4. Manufacturers:

   a. Hubbell DS220
   b. Leviton 5622
   c. Pass & Seymour 2622
   d. Cooper 7622

K. SW-2P-K; Key Lock Two Pole Switch:

1. Single throw, 120/277-volt, 20-amp maintained contact. Side and back wired. Provide key to Owner.
2. Manufacturers:

   a. Hubbell HBL1222L
   b. Leviton 1222-2L
   c. Pass & Seymour PS20AC2-L
   d. Cooper AH1222L

L. SW-3W; Three-way Switch:

1. 120/277 volt, 20 amp. Toggle handle, side and back wired.
2. Manufacturers:

   a. Hubbell 1223
   b. Leviton 1223-2
   c. Pass & Seymour PS20AC3
   d. Cooper AH1223

3. 120/277-volt, 20-amp maintained contact. Rocker handle, side and back wired.
4. Manufacturers:

   a. Hubbell DS320
   b. Leviton 5623
   c. Pass & Seymour 2623
   d. Cooper 7623

M. SW-3W-EM; Emergency Three-way Switch:

1. 120/277 volt, 20 amp. Red toggle handle, side and back wired.
2. Manufacturers:

   a. Hubbell 1223R
   b. Leviton 1223-2R
   c. Pass & Seymour PS20AC3-RED
   d. Cooper AH1223RD

N. SW-4W; Four-way Switch:

1. 120/277 volt, 20 amp. Toggle handle, side and back wired.
2. Manufacturers:

a. Hubbell 1224
b. Leviton 1224-2
c. Pass & Seymour PS20AC4
d. Cooper AH1224

O. SW-4W-EM; Emergency Four-way Switch:

1. 120/277 volt, 20 amp. Red toggle handle, side and back wired.
2. Manufacturers:

a. Hubbell HBL1224R
b. Leviton 1224-2R
c. Pass & Seymour PS20AC4-RED
d. Cooper AH1224RD

P. SW-COMB; Combination Single Pole Switch and GFCI Receptacle:

1. Single throw switch, 120-volt, 15-amp maintained contact. Toggle handle, side and back wired. NEMA 5-15R GFCI receptacle with test and reset buttons.
2. Manufacturers:

a. Hubbell GFSP15
b. Leviton 7229
c. Pass & Seymour 1595-SWTTR
d. Cooper VGFS15

2.6 WALL DIMMERS

A. UL listed with integral air-gap switch for on/off control.

B. Integral EMI/RFI suppression.

C. Non-viewable heat sink.

D. Dimmer compatibility and wiring with the load being controlled shall be verified by Contractor prior to purchase and installation.

E. Dimmer to match device color.

F. SW-D-LED; LED Electronic Driver Dimmer:

1. 120 277-volt, decora style linear slider operator with positive off. Color to match adjacent devices. Luminaire manufacturer shall list compatible dimmer manufacturers and models. 0-10V dimmers shall comply with IEC 60629 Annex E.
2. Manufacturers:

a. Compatible with provided LED driver.

G. SW-D3-LED; LED Electronic Driver Three-Way Dimmer:

1. 277-volt, decora style linear slider operator with positive off. Color to match adjacent devices. Luminaire manufacturer shall list compatible dimmer manufacturers and models. 0-10V dimmers shall comply with IEC 60929 Annex E.

2. Manufacturers:

   a. Compatible with provided LED driver.

H. SW-OD; Wall 0-10V Dimmer / Occupancy sensor:

1. Wall switch with manual on/auto off. 120VAC load rating of 0-800 W for electronic ballast, LED. 277VAC load rating of 0-1,800 W for electronic ballast, LED. adjustable OFF delay. 0-10V dimming with up to 30ma sink. Automatic ON/OFF, manual ON/automatic OFF, or occupancy on to predetermined dimming level go to last dimming setting upon occupancy.
2. Manufacturers:

   a. Sensor Switch WSX D Series

2.7 LOCAL DAYLIGHTING CONTROLS

A. Standalone Interior Photo Sensors:

1. SW-LS; Daylight Level Sensor - On/Off Control - One Zone:

   a. On/Off control. Range of 10-200 FC. Adjustable deadband prevents cycling. Adjustable time delay. 120/277 volt.
   b. Manufacturers:

      1) Watt Stopper LS-102
      2) Sensor Switch CM-PC
      3) Hubbell Automation DLCPC Series
      4) Greengate PPS-4

2. Sensor shall detect changes in ambient light level and provide triggering of lighting groups in area based on sequence of operation.
3. Sensor shall be configurable via DIP switches at device or via handheld wireless remote programming unit. Settings shall include:

   a. Ambient sensitivity range between 1 and 1,000 foot-candles.
   b. Time delay of 5 to 300 seconds.
   c. Trigger setpoints with deadband adjustment.

4. Sensor shall provide on/off setpoints in quantity as specified on drawings and as shown in the sequence of operation.
5. Sensor shall be ceiling- or wall-mounted for range and viewing angle meeting application requirements as outlined in the sequence of operation.
6. Output signal from sensor shall be linear with light level.

2.8 INDOOR OCCUPANCY AND VACANCY SENSORS

A. General Description: Wall- or ceiling-mounting, solid-state units with a separate power supply/relay unit.

1. Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied, with a time delay for turning lights off, adjustable over a minimum range of 1 to 30 minutes. Vacancy sensors require a manual switch operation to turn lights on and off, with a time delay for turning lights off when unoccupied.
2. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
3. Relay Unit: Dry contacts rated for 20 A ballast load at 120 and 277 VAC, for 13-amp tungsten at 120 VAC, and for 1 hp at 120 VAC. Power supply to sensor shall be 24 V dc, 150-mA, Class 2 power source as defined by Electrical Code.

4. Mounting:

    a. Sensor: Suitable for mounting in any position on a standard outlet box.
    b. Relay: Externally mounted through a 1/2-inch knockout in a standard electrical enclosure. Mount relay above accessible ceiling near entry door to room or area.
    c. Time Delay and Sensitivity Adjustments: Recessed and concealed.

5. Indicator: LED to show when motion is being detected during testing and normal operation of the sensor.
6. Bypass Switch: Override the on function in case of sensor failure.
7. Power Supply and Child Packs: Provide as required for sensor quantity and switching scheme. Mount to standard 1/2" knockout on electrical box above accessible ceiling near entry door to room or area. Sensor power shall be from emergency circuit if emergency lighting is in the area.
8. Detection Coverage (Room): Detect occupancy anywhere in an area based on hand motion.
9. Detection Coverage (Corridor): Detect occupancy based on a half-step motion.
10. Warranty: Five (5) year warranty.

B. Dual-Technology Type: Detect occupancy by using a combination of PIR and ultrasonic [or acoustic] detection methods in area of coverage. Particular technology or combination of technologies that controls on and off functions shall be selectable in the field by operating controls on unit.

1. SW-VS-D or SW-OC-D; 360 Degree Coverage Pattern:

    a. Frequency greater than 40 KHz. Dual sensing verifications (requires both technologies to activate), either technology maintains on status. Integrated ambient light level sensor (2 to 200 FC range), adjustable sensitivity and time delay, integrated isolated relay contact. Sensor shall control all circuits in area, unless noted otherwise. Initial settings: ambient sensor 40 FC.
    b. Manufacturers:

        1) Watt Stopper DT 300 Series
        2) Hubbell OMNI-DT2000 or ATD2000C
        3) Greengate OAC-DT
        4) Leviton OSC##-MOW

2. SW-O2; Wall Switch:

    a. Multi-relay wall switch with manual on/auto off for two separate loads. 120/277 VAC load relay rating of 0-800 W for ballast, LED or tungsten. 5-, 15-, 30-minute adjustable OFF delay. Coverage of minor motion in 12' x 15' pattern.
    b. Manufacturers:

        1) Watt Stopper DW-200 Series
        2) Hubbell LHMTD
        3) Leviton OSSMD series

3. Sensitivity Adjustment: Separate for each sensing technology.
4. Detection Coverage:

    a. Task Areas: Detect occupancy anywhere in an area based on hand motion.
    b. Circulation Areas: Detect occupancy anywhere in an area based upon half-step walking motion.

C. Mask sensors where necessary to prevent nuisance switching from adjacent areas.

Lighting Load	Load A	Load B
Step 1:	On	Off
Step 2:	Off	On
Step 3:	On	On
Step 4:	Off	Off

2.9 AUTOMATIC LOAD CONTROL RELAY (ALCR)

A. ALCR20; Automatic Load Control Relay ALCR, 120/277 volt, dry/damp listed, 32°F to 113°F (0°C to 45°C) operating temperature, plenum NEMA 1 rated, test button with visual indicator, remote test and fire alarm control, UL924 listed latest edition, Electrical Code Article 700 compliant.

1. Rating:

    a. 20 amp (16 A permitted) LED driver and ballast.
    b. 10 A (1,200 watt) incandescent.

2. Lighting Control Coordination: Provide ALCR device compatible with designated lighting zone controls. Example: switched, 0-10 volt dimming, DALI control, 2 wire dimming, or DMX.
3. Operation:

    a. ALCR device shall allow the same local lighting control devices to control both the normal lights and emergency designated lighting. Devices that require separate local lighting controls for the normal and designated emergency lighting are NOT allowed.
    b. ALCR device shall monitor the normal power circuit and shunt/bypass the local lighting controls upon loss of power, remote test switch, or fire alarm override to provide full lumen output for designated emergency lighting.
    c. ALCR device shall return designated emergency lighting to local lighting control after a 15-minute delay upon return of normal power or remote test/fire alarm override release.
    d. Equivalent Facilitation and Performance: A limitation of equivalent comparable products may require some of the required functions of the ALCR device to be provided by an alternative component of the lighting control system. The following functions may be performed by alternative components of the lighting control system when the device is listed for the required function and compatible with the lighting control system:

        1) Remote test switch / fire alarm override interface.
        2) The 15-minute time delay upon return of normal power or remote test/fire alarm override release.

    e. Accessory - Remote Test Switch: Provide a remote button test switch. The test switch shall be a single gang type switch compatible with the ALCR device and allow the remote fire alarm override to function.

        1) Test Switch Mounting:

            a) Finished Spaces (ceiling height 10 feet or less): Flush mount device in finished ceiling adjacent to one of the emergency lights.
            b) Finished Spaces (ceiling height greater than 10 feet): Flush mounted in wall. Refer to Architect/Engineer for location.
            c) Unfinished Spaces: Adjacent and aligned with local wall-mounted lighting controls.
            d) Option: ALCR device(s) with a test button, visual indicator, and flush mounting plate may be installed in the location of the remote test switch in lieu of providing a separate remote test switch.

4. Manufacturers:

    a. LVS Controls EPC-2 (switched)
    b. EPC-2-D Series (0-10V dimming)
    c. EPC-DMX (DMX) EPC Series (alternative lighting control)
    d. Iota ETS-20 (switched)
    e. ETC-20-DR (0-10V dimming)

f. ETC Series (alternative lighting control)
g. Myers Emergency Power Systems RLY-SW-2 (switched)
h. RLY-DIM-2D (0-10V dimming
i. RLY Series (alternative lighting control)
j. Nine24 Inc ELCR-R (switched)
k. ELCR-Z10 (0-10V dimming)
l. ELCR Series (alternative lighting control)
m. Lighting control manufacturer

2.10 DISTRIBUTED LIGHTING CONTROL

A. Manufacturers: as listed below meet the qualifications as outlined in this specification. Contractor is responsible for verifying that selected manufacturer is capable of furnishing the complete system as specified herein.

1. Acuity Controls nLight Series
2. Legrand Watt Stopper DLM Series
3. Hubbell Automation NX Series
4. Eaton Greengate RC3 Series (room-based system)
5. Osram Encelium Series
6. Lutron

B. System Description: The lighting control system shall be a network of remote modules connected to a digital network via network hubs and controlled through a system server / central station. Lighting control devices connect to the modules and communicate via the digital network with the system server.System includes all associated wiring, relay modules, photocells, switches, dimmers, time clock, occupancy sensors, network interfaces, and hubs. System shall utilize distributed relays modules, allowing these relay modules to be located above accessible ceilings in or adjacent to rooms they are controlling.

C. Control Devices: All occupancy sensors (ultrasonic, IR and dual technology type), photocells, switches, and timers shall be provided with system and designed to operate on system network. Supplemental power packs shall be provided as required for multiple control devices. This equipment shall be identified in shop drawing submission.

D. Relay Modules: Mounted in NEMA enclosure with physically separate 120/277-volt wiring compartment from low voltage control wiring. Provide low voltage digital communication to control devices as shown on drawings and schedules. Supplemental power packs shall be provided as required for multiple control devices. This equipment shall be identified in shop drawing submission. Dimmable relay modules shall be provided where indicated. Relay modules shall contain up to four (4) relays. Relay modules shall be labeled with room number that relays control lighting within.

E. Single-Pole Relays: Mechanically held unless otherwise indicated; split-coil, momentary-pulsed type, rated 20 A, 125-volt AC for tungsten filaments and 20 A, 277-volt AC for electronic ballasts, 50,000 cycles at rated capacity.

F. System shall include server / central station with operating software, data network, and BACnet IP communication with other systems as described. System communication protocol shall be compatible with the building automation system.

G. System server / central station shall provide programmable operation of lights connected via system relays and controlled with system devices. System software shall provide control of relays and control devices, time and sequence scheduling, timed out and blink light operation, and monitoring and reporting of system events and components. Initial programming shall be as shown on plans and schedules.

H. Server / Central Control Station: Lighting control system manufacturer shall be responsible to assure coordination between relay modules, network hubs, and control system server/ central station such that system performs as described. Server shall be provided with monitor, keyboard, and mouse, and plugged into a receptacle connected to an equipment emergency circuit as a minimum.

I. Network Hub: Network Hub shall contain processor and astronomic time clock for control and monitoring of lighting. Network hub shall be fed from an equipment emergency circuit at a minimum.

2.11 CENTRAL LIGHTING CONTROL - RELAY PANEL TYPE (NETWORK)

A. Manufacturers: listed below meet the qualifications as outlined in this specification. Contractor is responsible for verifying that selected manufacturer is capable of furnishing the complete system as specified herein.

1. WattStopper

B. System Description LCP-1; Lighting Control. Refer to schedules for size, rating, and configuration.

1. The lighting control system shall be a network of lighting relay panels connected to a digital network and controlled through a system server / central station. Lighting control devices connect to the relay panels and communicate via the panel controller with the system server. System includes all associated network interfaces and wiring, relay panels, control modules, input modules, panel processors, relays, photocells, switches, dimmers, time clock, and occupancy sensors.
2. System shall include server / central station with operating software, data network, and BACnet IP communication, with other systems as described. System communication protocol shall be compatible with the building automation system (BAS).
3. System server / central station shall provide programmable operation of lights connected via system relays and controlled with system devices. System software shall provide control of relays and control devices, time and sequence scheduling, timed out and blink light operation and monitoring and reporting of system events and components. Initial programming shall be as shown on plans and schedules.

C. Server / Central Control Station: Lighting control system manufacturer shall be responsible to assure coordination between system devices, network, and control system server/ central station such that system performs as described. Server / central control station shall have a minimum 80 GB hard drive, [2][4][8] GB RAM, 3 GHz speed minimum, three Ethernet ports, 1024 x 768 resolution graphic card, and 3 USB 2.0 ports. Server shall be provided with monitor, keyboard, and mouse, and plugged into a receptacle connected to an equipment emergency circuit as a minimum.

D. Cabinet: Steel with hinged, locking door. Barriers separate low-voltage and line-voltage components.

1. Typewritten Directory: Identifies each relay as to load controlled.

E. System Power Supply: Transformer and full-wave rectifier with filtered DC output for panel, controllers, and control devices. Feed from an equipment emergency circuit at a minimum.

F. Relays: Mechanically latched unless otherwise indicated; split-coil, momentary-pulsed type, rated 20°A, for tungsten filaments and NEMA for electronic ballast rated. Rated for 50,000 ON/OFF cycles at rated capacity.

G. Controllable Breaker (Option):

1. Solenoid operated thermal magnetic breakers to provide control, overload protection, and short circuit protection.
2. Ratings of 120/240V AC; 15, 20 and 30-amp; 1- and 2-pole, 277/480V AC, 15, 20 and 30-amp: 1 and 2-Pole. Minimum AIC rating to be 14,000 at 480Y/277 and 65,000 at 120/240.

H. Control Devices: All occupancy sensors (ultrasonic, IR and dual technology type), photocells, switches, and timers shall be provided with system and designed to operate on system network. Supplemental power packs shall be provided as required for multiple control devices. This equipment shall be identified in shop drawing submission.

I. Dimming Modules:

1. Dimming processor shall respond to control changes in less than 50 milliseconds.
2. Dimmers shall consist of the following components:

    a. Output Circuit Breakers: Circuit breakers shall be fully magnetic so that trip current is not affected by ambient temperature. Circuit breakers shall be rated for 100 percent switching duty. Dimmers shall accept hot patching of a cold incandescent load up to the full rated capacity of the dimmer.
    b. Each dimmer module shall use a solid-state relay (SSR) consisting of two SCRs in an inverse parallel configuration, and all required gating circuitry on the high-voltage side of an integral opto-coupled control voltage isolator.
    c. Toroidal filters shall limit objectionable harmonics, reduce lamp filament sing, and limit RF interference on line and load conductors. Rise times ranging from 200 to 500 microseconds shall be available depending upon model number selected.
    d. Power efficiency for standard dimmers shall be at least 96 percent at full load, with a no-load loss of three (3) volts RMS.

3. Non-dim Modules:

    a. Each plug-in module shall contain a magnetic circuit breaker and a relay rated to withstand hot patching of cold incandescent loads up to 20-amp module rating, without tripping.

J. Central Lighting Control Features and Functions:

1. Dimming system presets shall be programmable via preset/fader station directly at the control panel, or via network-based workstation software. Dimming presets shall have discrete fade times with 0.1 second resolution, programmable from zero to 24 hours, and shall be selectable via button, fader, clock event, macro or network interface.
2. Clock events shall be activated by calendar schedule, by day type and/or specific day programming, including every day, weekday, weekend, S, M, T, W, H, F, S, Holiday. Clock events shall also be activated by astronomical events, which will compensate for daylight savings time and will have programmable setback periods relative to sunrise and sunset.
3. The system shall be capable of implementing On commands, Off commands, Raise (dimming) commands, Lower (dimming) commands for any relay, group or zone by means of digital wall switches, specification grade line voltage type wall switches, photocell, web-based software or other devices connected to programmable inputs in a lighting control panel.
4. Channels for grouping relays shall be provided, each with an associated pushbutton to toggle the channel ON/OFF and a terminal block for a separate dry contact input. Any number of relays in the panel can be assigned to each channel, with overlapping allowed. Channels shall be set up via communication line communications and networking. Each channel pushbutton shall provide LED status indication. The panel shall also have the ability to assign functions to relays independently of the channels. Panels shall be addressable with DIP switches or other local means to set panel address.
5. System shall accept any type of switch input, including momentary or maintained.
6. System shall support by relay or zone the "blink warning" function. System shall be capable of flashing lights Off/On prior to the lights being turned Off. The warning interval time between the flash and the final lights off signal shall be definable for each zone. Occupant shall be able to override any scheduled Off sweep using local wall switches within the occupied space. Occupant override time shall be locally and remotely programmable and shall not exceed two (2) hours.
7. System shall provide temporary override conditions for each relay or dimmer so that lights can always be turned on.
8. All programming and scheduling shall be able to be done locally at the parent lighting control panel and remotely via the Internet. Remote connection to the lighting control system shall provide real-time control and real-time feedback. Lighting control system shall be able to be monitored by and take commands from a remote PC. At any time, should the remote PC go offline, all system programming uploaded to the lighting control system shall continue to operate as intended.
9. All programs, schedules, time of day, etc., shall be held in non-volatile memory for a minimum of two (2) years at power failure. At restoration of power, lighting control system shall implement programs required by current time and date.

K. BACnet or Facility Management Control System (FMCS) Protocol Interface: Provide BACnet-over-IP interface to building controls system or a Direct Digital Controls native protocol interface to read, control and monitor status of all lighting zones and groups in real time.

L. Ethernet Connection Port - Interoperability:

1. System shall include an Ethernet port for connection to Owner's TCP/IP network, permitting remote management of system from local or wide area network connection.
2. Contractor shall coordinate with technology vendor to provide an Ethernet connection to (LCP) panel as specified by manufacturer.

M. RS232 Interface for Audio/Visual Interface - Control Interface Stations:

1. Control interface stations shall provide an interface for PC and/or A/V connection to lighting control system.
2. Stations shall utilize RS-232 standard protocol and shall be appropriate DIN-style connector.

2.12 CENTRAL LIGHTING CONTROL INTERFACES

A. SW-LV; Manual Switches, Stations and Plates:

1. Switches: Modular, momentary pushbutton, with addressable capabilities to control the luminaires assigned to that switch. The switch shall be able to actuate the functions based on the described sequence of operation and intended functions.
2. Preset/fader stations shall operate using programmable buttons and/or faders as indicated on drawings.
3. Integral Pilot Light or LED: Indicate that controls are active or powered by being on continuously when powered or when pushbuttons are actuated.
4. Labeling of buttons and faders shall be engraved/screened by manufacturer, using approved text returned with shop drawing submittals.
5. Station control components shall be designed to operate standard default or custom system functions. Components shall operate default functions unless re-assigned via direct or network connection. Function options include: preset selection, manual mode, record mode, station lockout, raise/lower, macro, cue, and room join/separate.

B. Portable Control Console and Connector Station:

1. Portable control console with minimum 10-foot cable and interface plug.
2. Connector station receptacle, flush mounted, to allow portable console to communicate with lighting control system. Mounts in industry standard backbox.

C. LS-N; Network Daylight Level Sensor:

1. Networked sensors shall serve as a measurement device that provides ongoing read-back of sensor settings to lighting control network or daylight controller. Refer to the sequence of operation for actions to be triggered at various read-back values.
2. Sensor shall be ceiling- or wall-mounted for range and viewing angle, meeting application requirements as outlined in the sequence of operation. Outdoor sensors shall be wet location listed and designed specifically for outdoor use.
3. Output signal from sensor shall be linear with light level. Network connection permits remote query of sensor status and value via control software. All adjustments, with the exception of sensor range, shall be made via network connection.
4. Sensor shall have adjustable sensitivity range to permit use as scheduled.

2.13 TIME SWITCH

A. TC-1; Astronomical time switch, 7-day, 1 channel, electronic, one SPDT 5-amp contact, LCD display, 12 or 24-hour format, minimum 100 hours carryover, UL listed.

1. Manufacturers:

   a. Paragon EC71ST
   b. Tork DWZ100A
   c. Intermatic ET70115C

2.14 CONDUCTORS AND CABLES

A. Control Wiring:

1. Where installed with the line-voltage wiring, control wiring shall be copper conductors not smaller than No. 16 AWG with insulation voltage rating and temperature rating equal to that of the line-voltage wiring, complying with Division 26 Section 26 05 13 "Wire and Cable."
2. Tap conductors to switches or relays: Stranded copper conductors of 16 AWG or solid 16 or 18 AWG with insulation rating equal to that of the line-voltage wiring.
3. Tap conductors to dimming ballasts: Solid copper conductors of 18 AWG with insulation voltage rating equal to that of the line-voltage wiring and insulation temperature rating not less than 90°C.
4. Network cabling as required by manufacturer.

B. Splices and Taps:

1. Tapping or wire trap connectors shall be used to splice all Class 1 and Class 2 control wiring. Twist-on, wire-nut type connectors are not allowed.

PART 3 - EXECUTION

3.1 PRE-CONSTRUCTION MEETING

A. Schedule a pre-construction meeting with the controls representative, installing contractor, Architect/Engineer, and Owner to explain the proposed lighting control centralized, wireless, and distributed systems.

3.2 EXAMINATION

A. Verify that surfaces are ready to receive work.

B. Verify field dimensions and coordinate physical size of all equipment with the architectural requirements of the spaces into which they are to be installed. Allow space for adequate ventilation and circulation of air.

C. Verify that required utilities are available, in proper location, and ready for use.

D. Beginning of installation means installer accepts existing conditions.

3.3 INSTALLATION

A. Install in accordance with manufacturer's instructions and approved shop drawings.

B. All wiring shall be installed in conduit. Class II low voltage control wiring may be open wiring and shall maintain 150 mm (6 inch) spacing from electronic ballast and other RFI/EMI sources.

C. All branch load circuits shall be live tested before connecting the loads to the lighting control panel.

3.4 Automatic Load Control Relays (ALCR20) and Branch circuit emergency lighting transfer switch (bcelts)

A. Field install per manufacturer requirements.

B. Remote Test Switch: Provide connection to remote test switch.

C. Fire Alarm Override: Provide connection to addressable fire alarm relay.

3.5 SUPPORT SERVICES

A. System Startup:

1. Manufacturer shall provide factory authorized technician to confirm proper installation and operation of all system components.

B. Testing:

1. System shall be completely functional tested by a factory-authorized technician. All loads shall be tested live for continuity and freedom from defects, and all control wiring shall be tested for continuity and connections prior to energizing the system components.
2. Programming of initial zones, schedules, lighting levels, control station groups, and sensor settings shall be performed by a factory-authorized technician. Lighting Control Sequence of Operation shall serve as a basis for programming, However, all final decisions regarding groups and schedules shall be at the direction of the Owner. The following procedures shall be performed at a minimum:

 a. Confirm occupancy sensor placement, sensitivity, and time delay settings to meet specified performance criteria.
 b. Confirm daylight sensor placement, sensitivity, deadband, and delay settings to meet specified performance criteria.
 c. Confirm that schedules and time controls are configured to meet specified performance criteria and Owner's operating requirements.

3. Verify occupancy/vacancy and daylight sensor operation is correct after furniture and equipment is installed in each area. Make adjustments to sensor settings and time delays to allow proper operation.
4. Verify occupancy/vacancy sensors are located to provide complete coverage for the area served with no nuisance switching.

 a. Relocate sensors or provide additional sensors as necessary to provide adequate coverage.
 b. Mask occupancy sensors where necessary to prevent nuisance switching from adjacent areas.

C. Training:

1. Manufacturer shall provide competent factory-authorized technician to train Owner personnel in the operation, maintenance and programming of the lighting control system. Submit training plan with notification seven (7) days prior to proposed training dates.
2. Training duration shall be no less than three (3) days, with one (1) day being scheduled at least two (2) weeks after initial training.

D. Documentation:

1. Manufacturer shall provide system documentation including:

 a. System one-line showing all panels, number and type of control stations and sensors, communication line, and network or BMS/BAS interface unit.
 b. Drawings for each panel showing hardware configuration and numbering.
 c. Panel wiring schedules.
 d. Typical diagrams for each component.

3.6 SYSTEM COMMISSIONING

A. Contractors' tests shall be scheduled and documented in accordance with the commissioning requirements. Refer to Section 01 09 00, General Commissioning, for further details.

B. System verification testing is part of the commissioning process. Verification testing shall be performed by the Contractor and witnessed and documented by the Commissioning Agent. Refer to Section 01 09 00, General Commissioning, for system verification tests and commissioning requirements.

C. Training of the Owner's operation and maintenance personnel is required in cooperation with the Owner's Representative. The instruction shall be scheduled in coordination with the Owner's Representative after submission and approval of formal training plans. Refer to Section 01 09 00, General Commissioning, for Contractor training requirements.

END OF SECTION 26 09 33

SECTION 26 12 19 - PAD-MOUNTED, LIQUID-FILLED TRANSFORMERS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Liquid-filled, Pad-Mounted Distribution Transformers DTR-Insert #

1.2 QUALITY ASSURANCE

A. Manufacturer: Company specializing in distribution transformers with three (3) years documented experience.

1.3 REFERENCES (Use the latest revision of referenced standards.)

A. ANSI C57.12.70 - American National Standard Terminal Markings and Connections for Distribution and Power Transformers

B. ASTM D877.02e1 - Test Method for Dielectric Breakdown Voltage of Insulating Liquids Using Disk Electrodes

C. Department of Energy 10 CFR Part 431 - Energy Conservation Program for Commercial Equipment: Distribution Transformers Energy Conservation Standards; Final Rule.

D. IEEE C57.12.00 - Standard General Requirements for Liquid-Immersed Distribution, Power, & Regulating Transformers

E. IEEE C57.12.28 - Standard for Pad-Mounted Equipment - Enclosure Integrity

F. IEEE C57.12.34 - IEEE Standard Requirements for Pad-Mounted, Compartmental-Type, Self-Cooled, Three-Phase Distribution Transformers 5 MVA and Smaller; High Voltage, 34.5 kV Nominal System Voltage and Below; Low Voltage, 15 kV Nominal System Voltage & Below. (combines C57.12.22 and C57.12.26 of past.)

G. IEEE C57.12.80 - IEEE Standard Terminology for Power and Distribution Transformers

H. IEEE C57.12.90 - Standard Test Code for Liquid-Immersed Distribution Power, and Regulating Transformers

I. IEEE C57.106 - Guide for Acceptance and Maintenance of Insulating Oil in Equipment

J. IEEE C57.111 - Guide for Acceptance of Silicone Insulating Fluid and Its Maintenance in Transformers

K. IEEE C57.121 - Guide for Acceptance and Maintenance of Less Flammable Hydrocarbon Fluid in Transformers

L. NEMA 260 - Safety Labels for Pad-Mounted Switchgear and Transformers Sited in Public Areas

M. NEMA TR 1-1993 (R2000) - Transformers, Regulators and Reactors, Table 0-2 Audible Sound Levels for Liquid-Immersed Power Transformers.

N. NETA ATS - Acceptance Testing Specifications for Electrical Power Distribution Equipment (International Electrical Testing Association). Sections specific to transformers.

1.4 SUBMITTALS

A. Submit shop drawings and product data under the provisions of Section 26 05 00.

B. Shop drawings shall indicate electrical characteristics and field connection details, outline dimensions, connection and support points, weight, specified ratings and materials.

C. All transformer nameplate information shall be supplied on the submittal drawings. The transformer impedance information shall be part of the submittal information.

D. Where transformers are being supplied with integral fuses all details as to fuse make, fuse model, fuse ampere rating, and fuse time current curves applicable to transformer high voltage shall be supplied.

E. Coordination Drawings: Floor plans drawn to scale and coordinating floor penetrations and floor-mounted items. Show the following:

1. Underground primary and secondary conduit stub-up location.
2. Dimensioned concrete base, outline of transformer, and required clearances.
3. Ground rod and grounding cable locations.

F. Submit manufacturer's installation instructions under provisions of Section 26 05 00.

G. Submit equipment seismic certifications and seismic installation location anchoring/support/bracing sealed engineering details:

1. Manufacturer Seismic Qualification Certification:

   a. Submit certification that transformer assembly and components will withstand seismic forces defined in Section 26 05 48 Seismic Requirements for Equipment and Supports. Product data shall indicate standard model design tests and options. Certification testing shall meet the requirements of the applicable building codes. Equipment certification shall be based on the ability for the equipment to be returned to service immediately after a seismic event within the test requirements without the need for repairs.
   b. The equipment manufacturer shall provide dimensioned outline drawings of the equipment that identify the equipment center of gravity and locate plus describe the mounting and anchorage provisions.

2. Equipment Installation Contractor:

   a. In accordance with Section 26 05 48, the Contractor shall provide installation location, equipment anchorage details coordinated with the equipment manufacturer certification information and equipment manufacturer anchorage provisions. The anchorage details shall be prepared and stamped by the design Professional Engineer as required by the location/state in which the equipment is being installed.
   b. Provide detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Store and protect products under provisions of Section 26 05 00.

B. Protect transformers in storage from moisture by using appropriate heaters if instructed by the manufacturer.

1.6 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Section 26 05 00.

B. Include procedures for sampling and maintaining fluid, cleaning unit, and replacing components.

PART 2 - PRODUCTS

2.1 PAD-MOUNTED, LIQUID-FILLED TRANSFORMERS

A. Manufacturers:

1. Cooper Power Systems
2. General Electric
3. Howard Industries, Inc.
4. Schneider/Square D

B. Installation service conditions:

1. The transformer(s) shall be installed outdoors.
2. Transformer shall have dual wound primary (4,160/13,200 Volts).
3. The transformer shall be dead front type.
4. Transformer oil sampling ports must be accessible while transformer is energized.
5. The transformer will be used within C57.12.00 usual service conditions as follows:

    a. The cooling air ambient temperature shall not exceed 40°C (104°F), and the average temperature of the cooling air for any 24-hour period shall not exceed 30°C (86°F).
    b. The top liquid temperature of the transformer, when it is operating, shall not be lower than minus 20°C (minus 4°F).
    c. The altitude shall not exceed 1000 meters/3300 feet.

C. Description: Liquid-filled, pad-mounted, three-phase, two-winding transformers. Construction shall allow installation in locations accessible to the general public without the need for protective fencing or vaults.

D. The transformer shall be UL listed as follows:

1. The transformer shall have a UL Mark that the transformer is listed per UL XPLH. The Listing Mark shall include the UL symbol together with the word "LISTED", a UL control number, and the product name "Liquid-filled Distribution Transformer". The word "Transformer" may be abbreviated "XFMR", "XFRMR", or "XFORMER". This affirms that the transformer has been investigated by UL to UL-specified ANSI/IEEE standards stated in UL XPLH.

E. The transformer electrical power frequency shall be 60 hertz.

F. Transformer kVA shall be as specified on the project drawings. The transformers shall be self-cooled, and not have any forced cooling means, such as fans.

G. The transformer coils shall be wound with copper conductors.

H. The transformer primary/high voltage shall be as shown on the project drawings. The primary/high voltage winding configuration as delta or grounded-wye shall be as shown on the project drawings.

I. The transformer high voltage basic lightning impulse level BIL shall be 95 kV.

J. The transformer secondary/low voltage shall be as shown on the project drawings. The secondary/low voltage winding configuration as wye or delta shall be as shown on the project drawings. Where wye windings are specified, there shall be provisions for bonding the neutral terminal to ground at the transformer terminations.

K. The transformer low voltage BIL shall be 30 kV.

L. The transformer shall have a tap changer with the following full capacity, high voltage taps. The taps shall only be changed with the transformer de-energized. Provide an externally operable tap changer with tap position indicator and a means to padlock the tap changer at each position:

1. Two 2.5% taps above nominal voltage and two, 2.5-percent taps below rated, nominal voltage.

M. The transformer average winding temperature rise above ambient temperature at the transformer rating shall be as follows. The transformer shall be capable of being operated at rated load in a 30°C average ambient over 24 hours and a 40°C maximum ambient without loss of service life:

1. At the base transformer kVA rating, the rise above ambient shall not exceed 55°C, and at 112% of the base kVA rating, the rise above ambient shall not exceed 65°C.

N. Transformer percent impedance, as measured at the rated, nominal voltage connection, shall be per the following target impedances: The tolerance on the target impedances shall be ± 7.5% of nominal value for impedance target values greater than 2.5%.

1. Transformers with low voltage less than 600 VAC:

a. 112.5 kVA: Impedance target shall be 3.00%. Manufacturer shall submit target impedance on submittal.
b. 150 kVA: Impedance target shall be 3.75%. Manufacturer shall submit target impedance on submittal.
c. 225 to 300 kVA: Impedance target shall be 4.00%. Manufacturer shall submit target impedance on submittal.
d. 500 kVA: Impedance target shall be 4.50%. Manufacturer shall submit target impedance on submittal.
e. 750 to 3750 kVA: Impedance target shall be 5.75%. Manufacturer shall submit target impedance on submittal.

2. Transformers with low voltage above 600 VAC:

a. 1000 to 5000 kVA: BIL less than or equal to 150 kV. Impedance target shall be 5.75%. Manufacturer shall submit target impedance on submittal.

O. The transformer dielectric, liquid coolant shall be as follows:

1. Mineral oil transformer fluid" Mineral oil complying with ASTM D 3487, Type II, and tested according to ASTM D 117.

P. High Voltage Bushings and Terminals.

1. High voltage bushings shall be installed in the high voltage compartment located on the front left of the transformer.
2. The bushing style shall be:

a. Dead front rated for 15/25/35 kV (rated for transformer voltage class), with currents above 200 amps to 600 amps or below. The high voltage bushing shall be a 600-amp dead-break, one-piece bushing, externally front removable and shall be supplied with a removable stud. The bushings shall meet IEEE 386 requirements for dead-break terminations.

3. High Voltage Bushing Configurations.

a. 15/25 kV radial feed dead front. The transformer shall have three (3) high voltage bushings for terminating a conductor per phase using IEEE 386 style terminations. Provide a cable "parking stand" by each high-voltage bushing well. Provide an "insulated parking bushing" for parking IEEE 386 style, high-voltage cable terminators for each parking stand.

Q. Low Voltage Bushings and Terminals:

1. Low voltage bushings shall be supplied in the low voltage compartment located on the front right of the transformer.
2. Transformers with a low voltage of 600 volts or less shall be provided with tin-plated, spade-type bushings. The bushings shall be externally replaceable. The bushings shall be designed for vertical cable takeoff. The quantity of connection holes shall be 4, 6, 8, 12, 16, or 20 holes as necessary for the transformer low voltage conductor terminations. The spacing of the connection 9/16-inch holes shall be 1.75 inches on center per C57.12.34. Standard and maximum bushing hole quantities shall be as follows:

   a. 750-1500 kVA. 480Y/277 V: 6-holes standard

3. For transformers with a low voltage of 600 volts or less, bushing supports shall be provided for transformers that have ten or more connection holes.
4. For transformers with a low voltage of 600 volts or less, the bushing configuration shall be capable of terminating the number of cables allowed by the number of bushing holes specified.
5. For transformers with a low voltage greater than 600 volts, the bushing types shall be the same types as allowed in the transformer high voltage compartment. 4160 VAC transformer low voltages shall use 15 kV bushings when IEEE 386 type of terminations are specified.

R. Surge Arresters: External, distribution class, one for each primary phase; complying with IEEE C62.11 and NEMA LA 1; support from tank wall within high-voltage compartment. The transformer shall have three arresters for radial-feed. Arrester ratings shall be as follows:

High Voltage Line-to-Line	Arrester kV Delta Windings	Arrester kV GrdY Windings
4160 VAC	6 kV	3 kV
12470 VAC	15 kV	9 kV
13200 VAC	15 kV	10 kV
13800 VAC	15 kV	10 kV
22860 GRDY VAC	NA	18 kV
24940 GRDY VAC	NA	21 kV
34500 GRDY VAC	NA	30 kV

S. Transformer Tank and Cabinet Enclosure:

1. The high voltage and low voltage compartments shall be located side-by-side on one side of the transformer tank. The compartments shall be separated by a metal barrier. The access door to the high voltage compartment shall be provided whereby the high voltage compartment door can only be opened after the door to the low voltage compartment has been opened. There shall be one or more fastening devices that must be removed before the high voltage compartment door can be opened. The low voltage compartment door shall have, as a minimum, a three-point latching system with a handle with provisions for a pad lock. Door hardware shall be made of corrosion resistant material.
2. A recessed, captive, penta-head or hex-head bolt that meets the requirements of C57.12.28 shall secure all access doors. The transformer shall meet all tamper resistance requirements of C57.12.28.

3. The tank base shall be designed to allow skidding or rolling in any direction. Lifting lugs shall be provided on the tank to allow the transformer to be lifted from above. Jacking provisions shall be provided.
4. The transformer shall be of a sealed tank construction. The tank shall be able to withstand a pressure of 7 psi without any permanent deformation and a pressure of 15 psi without rupture.
5. The tank cover shall be welded and the transformer tank hand hole fastenings shall be tamper resistant.
6. The tank shall include a 15 psig pressure relief valve. The pressure relief valve capacity flow rate at 15 psig shall comply with UL listing requirements and, in no case, shall be less than 35 SCFM. The pressure relief device shall be self-sealing with an indicator.
7. The transformer exterior shall be painted olive-green color Munsell 7GY3.29/1.5. The interior of the transformer cabinets shall be painted for corrosion resistance. The cabinet interior shall be painted a light color for ease of viewing. The tank coating/painting shall meet all requirements of ANSI C57.12.28, including salt spray, cross hatch adhesion, humidity, impact, oil resistance, ultraviolet accelerated weathering, and abrasion resistance.

T. Accessories: The following accessories shall be provided on the pad-mounted liquid-filled transformers.

1. Nameplate in the low voltage compartment.
2. 1-inch upper fill plug.
3. 1-inch drain/sampling valve in low voltage compartment.
4. Dial-type thermometer gauge.
5. Liquid-level gauge.
6. Pressure-vacuum gauge.
7. Cover mounted, pressure relief device. Device shall be self-sealing with an indicator.

U. Transformer Sound Level: The transformer sound level, as measured by the NEMA audible sound-level test procedure, shall be less than the values specified in NEMA TR 1 for liquid -filled transformers.

V. Factory Standard Tests: The transformer shall be factory tested in accordance with IEEE C57.12.90. Tests include:

1. Ratio tests using all tap settings.
2. Polarity and phase relation tests.
3. No-Load losses tests.
4. Load loss tests.
5. Excitation current tests.
6. Percent Impedance at rated current.
7. Winding resistance measurement tests.
8. Induced and applied potential tests.
9. Full wave and reduced wave impulse test.
10. Mechanical leak test.

W. Certification of Transformer Tests: Provide certification of all design and other tests listed in C57.12.00, including verification that the design has passed short circuit criteria per IEEE C57.12.00 and C57.12.90.

2.2 IDENTIFICATION DEVICES (Project equipment tags)

A. Equipment Tag Nameplates: Engraved, laminated-plastic or metal nameplate for each transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Division 26 Section 26 05 53. (This is not the manufacturer's nameplate but the equipment tag for the specific use on the project.)

B. Transformer and equipment designations shall comply with MSU standard naming nomenclature.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that the transformer foundation/pads are ready to receive work.

B. Verify field dimensional measurements are as shown on the transformer shop drawings.

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 in accordance with manufacturer's instructions.

B. Install safety labels to NEMA 260.

C. Install plumb and level.

D. Install transformers, except for overhead pole type, on concrete bases.

1. Anchor transformers to concrete bases according to manufacturer's written instructions, seismic codes at the Project, and requirements in Division 26 Section "Seismic Controls for Electrical Work".
2. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit and 4 inches high.
3. Use 3000-psi, 28-day compressive-strength concrete and reinforcement as specified in Division 3 Section "Cast-in-Place Concrete Cast-in-Place Concrete (Limited Applications)".
4. Install dowel rods to connect concrete bases to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.
5. Install epoxy-coated anchor bolts for supported equipment that extends through concrete base and anchor into structural concrete floor.
6. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.

3.3 FIELD QUALITY CONTROL

A. Field testing will be performed under provisions of Section 26 05 00.

B. Inspect and test in accordance with NETA Acceptance Testing Specifications (ATS), except Section 4.

C. Perform inspections and tests listed in NEMA ATS, Section 7 relative to the NTEA category type "Transformers Liquid-Filled". Include the following optional tests:

1. In addition to the standard electrical tests, perform the following optional tests when applicable:

    a. Measure the percentage of oxygen in the gas blanket if a nitrogen gas blanket is provided.

2. In addition to insulating liquid standard tests, also include the following optional liquid tests:

    a. Specific gravity: ANSI/ASTM D 1298.
    b. Water in insulating liquids: ASTM D 1533.
    c. Power-factor or dissipation-factor in accordance with ASTM D924.

3.4 ADJUSTING

A. Adjust primary/high voltage taps so that secondary voltage is within 2% of rated voltage at projected load. Verify the projected load with Architect/Engineer prior to final settings.

END OF SECTION 26 12 19

SECTION 26 13 14 - PAD MOUNTED MEDIUM VOLTAGE SWITCHGEAR

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. "Medium Voltage Pad Mounted Switchgear" with compartmentalized interrupter switches with a common bus, in a single, self-supporting, low-height enclosure. Switchgear shall be suitable for use outdoors with underground, medium voltage electric power distribution. Source switch compartments shall have 3-pole, non-fused interrupter switches. Load switch compartments shall have, three, single-pole, fused interrupter switches. Enclosures shall be touch-safe and have integrity to not require fencing for additional protection.

B. Sectionalizing Cabinet

1.2 RELATED SECTIONS AND WORK

A. Refer to the One-Line Diagram for additional information.

1.3 QUALITY ASSURANCE

A. Manufacturer: Company specializing in medium voltage interrupter switches with five (5) years documented experience.

1.4 REFERENCES

A. NFPA 70E - National Electrical Safety Code

B. IEEE C37.74 - Standard Requirements for Subsurface, Vault, and Padmounted Load-Interrupter Switchgear and Fused Load-Interrupter Switchgear for Alternating Current Systems up to 38 KV

C. IEEE C57.12.28 - Standard for Pad-Mounted Equipment Enclosure Integrity

D. NFPA 70 - National Electrical Code (NEC)

1.5 SUBMITTALS

A. Submit shop drawings indicating outline dimensions, enclosure construction, shipping splits, lifting and supporting points, electrical single line diagram, and equipment electrical ratings under the provisions of Section 26 05 00.

B. Submit product data for components and accessories.

C. Submit manufacturer's installation instructions under provisions of Section 26 05 00.

1.6 EXTRA MATERIALS

A. Submit maintenance materials under provisions of Section 26 05 00.

B. Submit two (2) insulated-handle tools designed for operating single-pole switches and installing fuses.

C. Provide one (1) set of spare fuses of each size and rating under provisions of Section 26 05 00.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of Section 26 05 00.

B. Accept the switchgear on site and inspect for damage.

1.8 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Section 26 05 00.

B. Include fuse replacement, adjustment, and lubrication instructions.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. S&C Electric Company, Type. Vista Green, Model shall be 856242

2.2 -TEMP-MVS00; SWITCHGEAR COMPONENTS

A. Outdoor, pad-mounted switchgear consisting of compartments of 3-pole, non-fused, air-break, load-interrupter switches and compartments containing three, single-pole, fused, air-break load-interrupter switches, with all switches connected to a common bus structure within a single, self-supporting enclosure.

B. The quantity and type of switches required in each compartment shall be as shown on the project one-line drawing(s). The 3-pole, non-fused switch compartment shall be connected to incoming power sources or shall be used to continue power source distribution loops. The compartments with three, single-pole, fused switches shall be used for power distribution to loads.

C. The switchgear shall be manually operated.

D. The switchgear shall be used at an operating system operating voltage of 13.2 kV, three-phase, 60-hertz.

E. The switchgear main bus shall be rated 600 amperes, three-phase, 60-hertz, continuous.

F. The three-pole, load-interrupter switch compartment ratings shall be as follows:

1. Nominal voltage rating shall be a minimum of 14.4 kV.
2. Maximum voltage rating shall be a minimum of 17.5 kV.
3. The 3-pole switch BIL level shall be a minimum of 95 kV.
4. The 3-pole switch continuous current rating shall be 600 amperes.
5. The 3-pole switch load breaking / live switching capability shall be 600 amperes.
6. The 3-pole switch three-time duty-cycle fault-closing rating shall be a minimum of 36,400 amperes asymmetrical peak with a 14,000 amperes RMS symmetrical rating .
7. The 3-pole switch minimum short circuit rating shall be 36,400 amperes asymmetrical peak with a one-second short time withstand rating of 14,000 amperes RMS symmetrical l.
8. The 3-pole switch shall be handle-operated with an external handle to allow three-pole, live switching of three-phase source circuits. A folding switch-operating handle secured within the switch-operating hub access shall be provided for each 3-pole switch unit.

G. Single-pole, fused switch compartment ratings shall be as follows:

1. The fuse type shall be solid-material power fuses with an ampere rating value size (fuse E-size) as stated on the project drawings. The switch fuse mountings and fuses shall be:

a. S&C Electric SM-4 fuse units with holder, including silencer rated 14.4 kV nominal and 17.0 kV maximum. The maximum fuse size shall be 200E. The single-pole switch with this fuse shall have a 12,500 ampere RMS symmetrical short circuit / fault closing rating.

2. The single-pole switch with fuses shall have a 200 amperes RMS symmetrical load interrupting / dropping capability.
3. The single-pole switch with 14.4 kV fuses shall have a 95 kV BIL rating and with 25 kV fuses shall have a 125 kV BIL rating.
4. A compartment group of three, single-pole, fused switches shall be designed for hook stick operation of each fused switch.

H. The switchgear unit shall be UL listed, with the "UL Listed" symbol on the ratings label and nameplate.

2.3 ACCESSORIES

A. Provide cable guides in three-pole switch and bus compartments.

B. Provide cable guides in single-pole, fused switch compartments.

C. Provide an inner barrier panel inside the switchgear enclosure door for each compartment secured by a recessed pentahead bolt(s) to meet NESC and RUS requirements for dead-front.

D. Ground stud in all compartments. Ground studs shall be provided in all compartments for each switch, fuse, or bus terminal and ground pad. The momentary rating of the ground stud shall equal or exceed the short circuit rating of the switchgear.

E. Each fused interrupter switch compartment shall have built-in storage racks for spare fuse refills. Supply three spare fuse refills for each fused compartment.

F. Supply a switchgear hot stick fuse handling and single-pole switching tool (such as a Grappler) as recommended by the switchgear manufacturer with the switchgear. The tool shall be supplied with a universal pole / hot stick rated for the 14.4 kV or 25 kV switchgear for which it is being supplied.

G. Supply the following maintenance devices with the switchgear:

1. Shotgun style clamp stick for installation of grounding jumpers and for use with voltage testers. The shotgun style clamp stick provided shall be suitable for the voltage rating of the switchgear. Also supply a storage bag for the clamp stick.

H. The Electrical Contractor performing the field installation of cables to the switchgear shall supply and install outdoor rated, shielded cable termination kits with cable lugs. The cable lugs supplied by the Electrical Contractor shall be suitable for terminating the field-installed cable conductors to the switchgear cable terminal pads. The switchgear manufacturer shall provide clear and detailed information as to the lug requirements to terminate cable to the switchgear.

2.4 SWITCHGEAR FABRICATION

A. The enclosure shall be of 11 gauge cold-rolled steel. To prevent unauthorized entry, access to the enclosure shall be from the front and rear only, and side sheets shall not be externally bolted. Doors shall be of 11 gauge cold-rolled steel, bulkhead type construction and shall be full length.

B. Doors shall accommodate padlocking, and shall have latching mechanisms that withstand both outward and lateral forces.

C. The compartment doors shall have a pentahead type of latch mechanism whereby the doors can only be opened with a pentahead socket wrench or tool.

D. The complete assemblies shall be integrally designed and produced by the manufacturer of the basic switching components. Furthermore, it shall be constructed in accordance with the minimum construction specifications of the fuse manufacturer to provide adequate space for fuse handling, and, if required for fuse exhaust, sufficient volume and venting, plus the necessary enclosure strength and rigidity.

E. At each interrupter switch or fused interrupter switch bay, a fiberglass reinforced polyester end barrier shall prevent inadvertent access when the enclosure door is opened.

F. A front barrier of insulated material shall be provided for each switch and fuse. Where the National Electric Safety Code applies, these barriers shall meet the requirement of Section 31G. When the switch or fuse is in the open position, the barrier can be inserted into the open gap to guard against inadvertent contact with live parts. Interphase and end barriers of the same insulating material shall be provided with each switch and each set of fuses as necessary to achieve required BIL ratings.

G. The integrated assembly, interrupter switches, power fuses, and enclosures shall safely withstand the effects of closing, carrying, and interrupting all possible currents up to the maximum short circuit rating of the switchgear.

H. Hazard Alerting Signs and Labels:

1. All external doors providing access to high voltage shall be provided by the switchgear manufacturer, with a suitable hazard alerting sign.
2. The inside of all doors providing access to high voltage shall be provided by the switchgear manufacturer, with a suitable hazard alerting sign.
3. Switch compartments shall be provided by the switchgear manufacturer, with a hazard sign indicating that switches may be energized by backfeeds.
4. Fuse compartments shall be provided by the switchgear manufacturer, with a hazard sign indicating that fuses may be energized by backfeeds.
5. Barriers used to prevent access to energized parts shall be provided by the switchgear manufacturer, with suitable hazard alerting signs.

I. Nameplates, Connection Diagrams, and Ratings:

1. The outside of each of the doors providing access to high voltage shall be provided with a nameplate indicating the manufacturer's name, catalog number, model number, date of manufacture, and serial number.
2. The inside of the doors shall be provided with ratings label indicating the following:

    a. Overall pad-mounted switchgear ratings including nominal voltage kV, maximum voltage kV, BIL voltage kV, power frequency in hertz, short circuit peak withstand current in amperes, short circuit one-second short- time withstand current in amperes RMS symmetrical, and short circuit MVA, three-phase symmetrical at rated nominal voltage.
    b. Main bus ratings including continuous current in amperes, peak withstand current in amperes, and one-second, short-time withstand current in amperes RMS symmetrical.
    c. Switch ratings including continuous current in amperes, load switching and load dropping current in amperes, peak withstand current in amperes, one-second, short-time withstand current in amperes RMS symmetrical, and three-time duty cycle fault closing current in amperes RMS symmetrical.
    d. Fuse type and integral load interrupter ratings including maximum current in amperes, load switching and load dropping current in amperes, and duty-cycle, fault-closing current in amperes RMS symmetrical.

3. Include a three-line connection diagram showing the interrupter switches, fuses with integral load interrupters, and bus, along with the manufacturer's model number, on the inside of each door and on the inside of each switch operating hub access cover.

2.5 FACTORY FINISHING

A. Clean surfaces before applying paint.

B. Apply corrosion-resisting primer to all surfaces.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Deliver to job site and install in accordance with the manufacturer's instructions.

END OF SECTION 26 13 14

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SECTION 26 22 00 - DRY TYPE TRANSFORMERS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Dry type two winding transformers (TR-#)

1.2 REFERENCES

A. NEMA - ST 1 - Specialty Transformers

B. NEMA ST 20 - Dry Type Transformers for General Applications

C. ANSI/IEEE C57.12.01 - General Requirements for Dry Type Distribution and Power Transformers

D. ANSI/IEEE C57.12.91 - Test Code for Dry Type Distribution and Power Transformers

E. Department of Energy 10 CFR Part 431 - Energy Conservation Program for Commercial Equipment: Distribution Transformers Energy Conservation Standards; Final Rule.

F. NEMA TP 2 - Standard Test Method for Measuring the Energy Consumption of Distribution Transformers

G. NEMA TP 3 - Standard for the Labeling of Distribution Transformer Efficiency

1.3 SUBMITTALS

A. Submit product data under provisions of Section 26 05 00.

B. Include outline and support point dimensions of enclosures and accessories, unit weight, voltage, KVA, and impedance ratings and characteristics, loss data, efficiency at 35, 50, 75 and 100 percent rated load, sound level, tap configurations, insulation system type, and rated temperature rise.

1.4 DELIVERY, STORAGE, AND HANDLING

A. Store and protect products under provisions of Section 26 05 00.

B. Store in a warm, dry location with uniform temperature. Cover ventilating openings to keep out dust.

C. Handle transformers using only lifting eyes and brackets provided for that purpose. Protect units against entrance of rain, sleet, or snow if handled in inclement weather.

PART 2 - PRODUCTS

2.1 DRY TYPE TWO WINDING TRANSFORMERS

A. Acceptable Manufacturers:

1. Square D 7400 EX##T / SK300##KB Series

2. ABB 9T Series

B. Dry Type Transformers: NEMA ST 20, factory-assembled, air-cooled dry type transformers; ratings as shown on the drawings. Transformers supplied under this project shall meet the US Department of Energy (DOE) 2016 Efficiency requirements or the most current DOE CFR in effect.

C. Insulation system and average winding temperature rise for rated KVA as follows:

Ratings	Class	Rise (degree C)
Less than 15	185	As shown on the drawings
or higher	220	As shown on the drawings

D. Case temperature shall not exceed 40°C rise above ambient at its warmest point.

E. Winding Taps, Transformers Less than 15 KVA: Two 5 percent below rated voltage, full capacity taps on primary winding.

F. Winding Taps, Transformers 15 KVA and Larger: Two (2) 2-1/2% below and two (2) 2-1/2% above rated voltage, full capacity taps on primary winding.

G. Sound Levels: Average audible sound level shall not exceed the values given below when tested to NEMA ST 20 standards:

	Average Sound Level, Decibels			
	Self-Cooled Ventilated			Self-Cooled Sealed
Equivalent Winding kVA Range	K-Factor = 1 K-Factor = 4 K-Factor = 9	K-Factor = 13 K-Factor = 20	Forced Air w/ Fans Running	
0-9	40	40	67	45
9.01-30.00	45	45	67	50
30.01-50.00	45	48	67	50
50.01-150.00	50	53	67	55
150.01-300.00	55	58	67	57
300.01-500.00	60	63	67	59
500.01-700.00	62	65	67	61
700.00-1000.00	64	67	67	63

H. Ground core and coil assembly to enclosure by means of a visible flexible copper grounding strap.

I. Mounting: Transformers 75 KVA and less shall be suitable for wall, floor, or trapeze mounting; transformers larger than 75 KVA shall be suitable for floor or trapeze mounting.

J. Coil Conductors: Continuous windings with terminations brazed or welded.

K. Enclosure: NEMA ST 20; Type 1. Provide lifting eyes or brackets.

L. Isolate core and coil from enclosure using vibration-absorbing mounts.

M. Nameplate: NEMA TP 3; Include transformer connection data and overload capacity based on rated allowable temperature rise.

2.2 ACCESSORIES

A. Electronic Isolation Shield:

1. Provide electrostatic winding shield with separate insulated grounding connection as shown on the drawings.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Set transformer plumb and level.

B. Use flexible conduit, 2 feet minimum length, for connections to transformer case. Make conduit connections to side panel of enclosure.

C. Mount transformers on four 3”x3”x1/2” thick, 50 durometer rubber vibration isolating pads suitable for isolating the transformer noise from the building structure.

D. Ventilated transformers: Provide factory label on horizontal surface to prohibit storage on top, front, or adjacent to transformer.

3.2 FIELD QUALITY CONTROL

A. Check for damage and tight connections prior to energizing transformer.

B. Measure primary and secondary voltages and make appropriate tap adjustments. Adjustments shall be made at completion of project and at approximately 6 months following project acceptance when requested by the Owner.

END OF SECTION 26 22 00

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SECTION 26 24 13 - SWITCHBOARDS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Main and distribution switchboards: SB-#

1.2 RELATED SECTIONS AND WORK

A. Refer to the Electrical Distribution Diagram and Electrical Schedules for size, rating, and configuration.

1.3 REFERENCES

A. ANSI C12 - Code for Electricity Metering

B. ANSI C39.1 - Requirements for Electrical Analog Indicating Instruments

C. ANSI C57.13 - Requirements for Instrument Transformers

D. NEMA AB 1 - Molded Case Circuit Breakers

E. NEMA KS 1 - Enclosed Switches

F. NEMA PB 2 - Dead Front Distribution Switchboards

G. NEMA PB 2.1 - Instructions for Safe Handling, Installation, Operation and Maintenance of Deadfront Switchboards Rated 600 Volts or less

1.4 SUBMITTALS

A. Submit product data under provisions of Section 26 05 00.

B. Include front and side views of enclosures with overall dimensions shown; conduit entrance locations and requirements; nameplate legends; size and number of bus bars per phase, neutral, and ground; switchboard instrument details; instructions for handling and installation of switchboard; and electrical characteristics including voltage, frame size and trip ratings, withstand ratings, and time-current curves of all equipment and components.

C. Selective Coordination Study: Submit study to prove that all essential electrical systems, emergency systems and legally required standby system panelboards are selectively coordinated with all supply side overcurrent protective devices.

D. Arc Energy Reduction Documentation: Submit documentation to demonstrate the arc energy reduction system is set to operate at a value below the available arcing current.

E. Submit manufacturer's instructions under provisions of Section 26 05 00.

1.5 SPARE PARTS

A. Keys: Furnish four each to the Owner.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the site under provisions of Section 26 05 00.

B. Deliver in 48-inch maximum width shipping splits, unless approved otherwise by both the Contractor and Architect/Engineer, individually wrapped for protection, and mounted on shipping skids.

C. Store and protect products under provisions of Section 26 05 00.

D. 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.

E. Handle in accordance with NEMA PB2.1 and manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to switchboard internal components, enclosure, and finish.

1.7 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Section 26 05 00.

B. Include spare parts data listing; source and current prices of replacement parts and supplies; and recommended maintenance procedures and intervals.

PART 2 - PRODUCTS

2.1 GENERAL

A. Approved Manufacturers:

1. Square D Class 2700 QED-2, I-Line, Powerstyle

2.2 RATINGS

A. Definitions:

1. Series rated equipment shall be defined as equipment that can achieve a required UL AIC rating with an upstream device such as a main breaker or a combination of devices to meet or exceed a required UL AIC rating. All series rated equipment shall have a permanently attached nameplate indicating that device rating must be maintained. Refer to Section 26 05 53 for additional requirements.
2. Fully rated equipment shall be defined as equipment where all devices in that equipment shall carry a minimum of the AIC rating that is specified.

B. The switchboards for this project shall be fully rated.

2.3 SWITCHBOARD CONSTRUCTION AND RATINGS

A. Factory-assembled, dead front, metal-enclosed, and self-supporting switchboard assembly conforming to NEMA PB2, and complete from incoming line terminals to load-side terminations.

B. Switchboard electrical ratings and configurations as shown on the drawings.

C. Line and Load Terminations: Accessible from the front only of the switchboard, suitable for the conductor materials used.

D. Main Section Devices: Individually mounted and compartmented.

E. Distribution Section Devices: Group mounted.

F. Auxiliary Section Devices: Individually mounted and compartmented.

G. Bus Connections: Bolted, accessible from front only for maintenance. Plug-on connections may be utilized with Architect/Engineer's pre-approval by addenda.

H. Bus bars shall be fully isolated, braced for minimum ampere rms symmetrical rating as indicated on drawings.

I. The bus shall extend the full height of the distribution sections to provide space for future breakers.

J. Provide a 1 X 1/4-inch copper ground bus through the length of the switchboard.

K. Provide metering transformer compartment for Utility Company's or Owner's use. Compartment size, bus spacing and drilling, door, and locking and sealing requirements shall be in accordance to Section 26 20 00 and Utility Company specifications.

L. Enclosure shall be NEMA PB 2; Type 1 - General-Purpose. Sections shall align at front and rear. Provide removable panel access or hinged door with flush lock and all keyed alike. Door hardware shall provide swing clear operation (180-degree swing).

M. Switchboard Height: NEMA PB 2; 92 inches, excluding floor sills, lifting members and pull boxes.

N. Finish: Manufacturer's standard light gray enamel over external surfaces. Coat internal surfaces with minimum one coat corrosion-resisting paint, or plate with cadmium or zinc.

O. Future Provisions: In addition to the spare devices shown, provide a minimum of 48 inches of fully equipped space for future devices with bussing and bus connections, suitably insulated and braced for short circuit currents. Continuous current rating as indicated on the drawings.

P. Suitable for use as service entrance equipment. Provide line side (service style) barriers.

2.4 SWITCHING, OVER-CURRENT PROTECTIVE DEVICES, AND ARC ENERGY REDUCTION

A. Molded Case Circuit Breakers: Provide circuit breakers with integral thermal and instantaneous magnetic trip in each pole. Provide breaker interrupting ratings as indicated on the plans. Where necessary to meet interrupting ratings, breakers shall be provided with automatically resetting current limiting elements in each pole.

B. Solid State Molded Case Circuit Breakers: (All breakers identified on plans as solid-state with 2,500 ampere frame sizes and below.) Provide molded case switch with electronic sensing, timing, and tripping circuits for fully adjustable time current characteristic settings including, instantaneous trip, long time trip, long time delay, short time trip, and short time delay. Trip setting shall be field programmable with a sealable clear cover. Provide stationary mounting. Provide breaker interrupting ratings as indicated on the plans.

C. Arc Energy Reduction:

1. Provide an arc energy reduction system to reduce the clearing time of an arc flash event. The arc energy reduction system shall be provided for overcurrent protection devices rated 1,200 amps or larger.

2. Energy-Reducing Maintenance Switch: Provide an energy-reducing maintenance switch visual status indication when engaged. Install the maintenance switch in the first section of the electrical equipment.

2.5 INSTRUMENTS AND SENSORS

A. Current Transformers: ANSI C57.13; 5 ampere secondary, bar or window type, with single secondary winding, unless otherwise required for application, and secondary shorting device, primary/secondary ratio as required, burden and accuracy consistent with connected metering and relay devices, 60 Hertz.

B. Potential Transformers: ANSI C57.13; 120-volt single secondary, disconnecting type with integral fuse mountings, primary/secondary ratio as required, burden and accuracy consistent with connected metering and relay devices, 60 Hertz.

C. Electronic Power Monitor: Provide metering for local readings, basis of design: Square D PM8000. Provide Power Logic metering capable of direct connection to JCI Metasys Building Automation System for collection of usage and demand data as well as service status. Provide meter with BACnet MSTP. Connection to the Building Management System shall not require connection to the campus network.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install switchboard in locations shown on the drawings, in accordance with manufacturer's written instructions and NEMA PB 2.1.

B. Tighten accessible bus connections and mechanical fasteners after placing switchboard.

C. Install fuses in each switch.

3.2 FIELD QUALITY CONTROL

A. Inspect completed installation for physical damage, proper alignment, anchorage, and grounding.

B. Measure insulation resistance of each bus section phase to phase and phase to ground for one minute each. Test voltage shall be 1000 volts, and minimum acceptable value for insulation resistance is 2 megohms.

C. Check tightness of accessible bolted bus joints using a calibrated torque wrench. Tightness shall be in accordance with manufacturer's recommended values.

D. Physically test key interlock systems to ensure proper function.

3.3 ADJUSTING AND CLEANING

A. Adjust all operating mechanisms for free mechanical movement.

B. Touch up scratched or marred surfaces to match original finish.

C. Provide time/current trip curves for all adjustable protection devices that require setting. Also provide curves and equipment information for associated new and existing fixed devices that require coordination with new protection devices. Submit time/current curves in hard copy or electronic format.

D. Adjust trip and time delay settings to values as scheduled, or as instructed by the Architect/Engineer.

E. Where two levels of ground fault are provided, test ground fault circuit breakers to prove selective coordination in accordance with manufacturer's directions. Provide testing documentation with Operating & Maintenance Manual submittals.

END OF SECTION 26 24 13

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SECTION 26 24 16 - PANELBOARDS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Service and distribution panelboards: DP-#, DP-#

B. Lighting and appliance branch circuit panelboards: Panel '###'

C. Fusible branch circuit panelboards: Panel '###'

1.2 RELATED SECTIONS AND WORK

A. Refer to the Electrical Distribution Diagram and Electrical Schedules for size, rating, and configuration.

1.3 REFERENCES

A. NEMA AB 1 - Molded Case Circuit Breakers

B. NEMA FU 1 - Low voltage cartridge fuses

C. NEMA KS 1 - Enclosed Switches

D. NEMA PB 1 - Panelboards

E. NEMA PB 1.1 - Instructions for Safe Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less

F. NEMA PB 1.2 - Application Guide for Ground-fault Protective Devices for Equipment

G. UL 248 - Low-Voltage Fuses

H. UL 67 - Panelboards

1.4 SUBMITTALS

A. Submit shop drawings for equipment and component devices under provisions of Section 26 05 00.

B. Include outline and support point dimensions, voltage, main bus ampacity, integrated short circuit ampere rating, circuit breaker and fusible switch arrangement and sizes.

C. Selective Coordination Study: Submit study to prove that all essential electrical systems, emergency systems and legally required standby system panelboards are selectively coordinated with all supply side overcurrent protective devices.

D. Arc Energy Reduction Documentation: Submit documentation to demonstrate the arc energy reduction system is set to operate at a value below the available arcing current.

E. Submit manufacturer's instructions under provisions of Section 26 05 00.

1.5 SPARE PARTS

A. Keys: Furnish four (4) each to the Owner.

B. Fuses: Furnish 10% or a minimum of three (3) spare fuses of each type and rating installed to the Owner.

C. Fuse Pullers: Furnish one (1) fuse puller to the Owner.

PART 2 - PRODUCTS

2.1 RATINGS

A. Definitions:

1. Series rated equipment shall be defined as equipment that can achieve a required UL AIC rating with an upstream device such as a main breaker or a combination of devices to meet or exceed a required UL AIC rating. All series rated equipment shall have a permanently attached nameplate indicating that device rating must be maintained. See Section 26 05 53 for additional requirements.
2. Fully rated equipment shall be defined as equipment where all devices in that equipment shall carry a minimum of the AIC rating that is specified.

B. The panelboards for this project shall be fully rated unless otherwise specifically noted in the Drawings or Specifications.

2.2 MAIN AND DISTRIBUTION PANELBOARDS

A. General

1. Manufacturers:

a. Square D QMB, I-Line

B. Panelboards: NEMA PB 1; type as shown on the drawings.

C. Enclosure: NEMA PB 1; Type 1.

D. Provide cabinet front with concealed trim clamps and hinged trim on door to allow access to wiring gutters without removal of trim and flush lock. Door hardware shall provide swing clear operation (180-degree swing). Finish in manufacturer's standard gray enamel.

E. Provide panelboards with copper bus, ratings as scheduled on the drawings. Provide copper ground bus in all panelboards.

F. All spaces shown on the one-line diagram shall be fully prepared spaces for future breakers.

G. Minimum Integrated Short Circuit Rating: 100,000 amperes rms symmetrical for 240-volt panelboards; 50,000 amperes rms symmetrical for 480-volt panelboards, or as shown on the drawings.

H. Fusible Switch Assemblies: NEMA KS 1; quick-make, quick-break, load interrupter enclosed knife switch with externally operable handle. Provide interlock to prevent opening front cover with switch in ON position. Handle lockable in OFF position.

I. Fuse Clips (Switches 600 Amperes and Smaller): Provide with Class 'R' rejection clips. Fuse Clips (601 Amperes and Larger): Designed to accommodate Class 'L' fuses.

J. Molded Case Circuit Breakers: Provide circuit breakers with integral thermal and instantaneous magnetic trip in each pole.

K. Molded Case Circuit Breakers with Current Limiters: Provide circuit breakers with replaceable current limiting elements, in addition to integral thermal and instantaneous magnetic trip in each pole.

L. Current Limiting Molded Case Circuit Breakers: Provide circuit breakers with integral thermal and instantaneous magnetic trip in each pole, coordinated with automatically resetting current limiting elements in each pole. Interrupting rating 100,000 symmetrical amperes, let-through current and energy level less than permitted for same size Class RK-5 fuse.

M. Solid State Molded Case Circuit Breakers: (All breakers identified on plans as solid-state with 1,200 ampere frame sizes and below.) Provide molded case switch with electronic sensing, timing, and tripping circuits for fully adjustable time current characteristic settings including ground fault trip, instantaneous trip, long time trip, long time delay, short time trip, and short time delay. Trip setting shall be field programmable with a sealable clear cover.

N. Arc Energy Reduction:

1. Provide an arc energy reduction system to reduce the clearing time of an arc flash event. The arc energy reduction system shall be provided for overcurrent protection devices rated 1,200amps or larger.
2. Energy-Reducing Maintenance Switch: Provide an energy-reducing maintenance switch visual status indication when engaged. Install the maintenance switch in the first section of the electrical equipment.

2.3 BRANCH CIRCUIT PANELBOARDS

A. General

1. Manufacturers:

a. Square D NQ, NF

B. Lighting and Appliance Branch Circuit Panelboards: NEMA PB 1; circuit breaker type.

C. Enclosure: NEMA PB 1; Type 1.

D. Provide cabinet front with door-in-door construction, concealed hinge, and flush lock all keyed alike. Door hardware shall provide swing clear operation (180-degree swing). Finish in manufacturer's standard gray enamel.

E. Provide panelboards with copper bus, ratings as scheduled on the drawings. Provide copper ground bus in all panelboards.

F. All unlabeled circuits shown on the panelboard schedule shall be fully prepared spaces for future breakers.

G. All multiple-section panelboards shall have the same dimensional back box and cabinet front size.

H. Minimum Integrated Short Circuit Rating: As shown on the drawings.

I. Provide handle lock-on devices for all breakers serving exit sign and lighting circuits with emergency battery units. Provide handle lock-on devices and red handles for breakers serving fire alarm panels.

J. Molded Case Circuit Breakers: Bolt-on type thermal magnetic trip circuit breakers, with common trip handle for all poles. Provide circuit breakers UL listed as Type SWD for lighting circuits. Provide UL Class A ground fault interrupter circuit breakers where scheduled on the drawings. Do not use tandem circuit breakers.

K. Current Limiting Molded Case Circuit Breakers: Provide circuit breakers with integral thermal and instantaneous magnetic trip in each pole, coordinated with automatically resetting current limiting elements in each pole. Interrupting rating 100,000 symmetrical amperes, let-through current and energy level less than permitted for same size Class RK-5 fuse.

L. Suitable for use as service entrance equipment. Provide line side (service style) barriers.

2.4 FUSIBLE BRANCH CIRCUIT PANELBOARDS

A. General

1. Manufacturers:

a. Bussmann
b. Littelfuse
c. Siemens SQSCP
d. Mersen MFCP

B. Provide cabinet front with concealed hinge and flush lock all keyed alike. Finish in manufacturer's standard gray enamel.

C. Provide panelboards with copper bus, ratings as scheduled on the drawings. Provide copper ground bus in all panelboards.

D. Overcurrent protective devices shall be UL listed, with voltage, amperage, number of poles, and short-circuit current rating as shown on the panelboard schedule. Multi-pole branch circuit protection devices shall trip on an overcurrent of any pole to prevent single-phasing of the load.

E. Fuse holder shall be finger-safe with trim installed. Fuses shall only be removable when terminals are not energized.

F. All unlabeled circuits shown on the panelboard schedule shall be fully prepared spaces for future fuse units.

G. All multiple-section panelboards shall have the same dimensional backbox and cabinet front size.

H. Minimum Integrated Short Circuit Rating: As shown on the drawings.

I. Branch fuse disconnect shall have visible ON/OFF indication, blown fuse indicating lights, and permanently installed lockout means.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install panelboards plumb as indicated on the drawings in conformance with NEMA PB 1.1.

B. Height: 6 feet to handle of highest device.

C. Provide filler plates for unused spaces in panelboards.

D. Provide custom typed circuit directory for each branch circuit panelboard. Provide updated custom typed circuit directory for each existing branch circuit panelboard with new or revised circuits per the scope of work. Label shall include equipment name or final approved room name, room number, and load type for each circuit (examples: SUMP SP-1 or ROOM 101 RECEPT). Revise directory to reflect circuit changes required to balance phase loads. Printed copies of the bid document panel schedules are not acceptable as circuit directories.

E. Stub five (5) empty one-inch conduits to accessible location above ceiling out of each recessed panelboard.

3.2 FIELD QUALITY CONTROL

A. Measure steady state load currents at each panelboard feeder. Should the difference at any panelboard between phases exceed 20 percent, rearrange circuits in the panelboard to balance the phase loads within 20 percent. Take care to maintain proper phasing for multi-wire branch circuits.

B. Visual and Mechanical Inspection: Inspect for physical damage, proper alignment, anchorage, and grounding. Check proper installation and tightness of connections for circuit breakers, fusible switches, and fuses.

END OF SECTION 26 24 16

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SECTION 26 24 19 - MOTOR CONTROL

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Manual motor starters and switches

B. Magnetic motor starters

C. Combination magnetic motor starters

1.2 RELATED SECTIONS AND WORK

A. Refer to the Disconnect and Starter Schedule and One-Line Diagram for rating and configuration.

1.3 REFERENCES

A. ANSI/UL Standard 508. Standard for Industrial Control Equipment

B. FCC Rules and Regulations, Part 15, Subpart J- Radio Frequency Interference

C. FS W-C-375 - Circuit Breakers, Molded Case; Branch Circuit and Service

D. FS W-F-870 - Fuseholders (For Plug and Enclosed Cartridge Fuses)

E. FS W-P-115 - Power Distribution Panel

F. FS W-S-865 - Switch, Box, (Enclosed), Surface-Mounted

G. IEEE Standard 519-1981 - Guide for Harmonic Control and Reactive Compensation of Static Power Converters

H. NEMA AB 1 - Molded Case Circuit Breakers

I. NEMA ICS 2 - Industrial Control Devices, Controllers, and Assemblies

J. NEMA ICS 6 - Enclosures for Industrial Controls and Systems

K. NEMA KS 1 - Enclosed Switches

L. NEMA PB 1 - Panelboards

M. NEMA PB 1.1 - Instructions for Safe Installation, Operation and Maintenance of Panelboards Rated 600 Volts or less

1.4 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 26 05 00.

B. Indicate on shop drawings, front and side views of motor control center enclosures with overall dimensions. Include conduit entrance locations and requirements; wiring diagrams that differentiate between manufacturer-installed and field-installed wiring; nameplate legends; size and number of bus bars per phase,[**neutral,**] and ground; electrical characteristics including voltage, frame size and trip ratings, withstand ratings, and time-current curves of all equipment and components.

C. Provide product data on motor starters and combination motor starters, relays, pilot devices, and switching and over-current protective devices.

D. Submit manufacturer's instructions under provisions of Section 26 05 00.

1.5 SPARE PARTS

A. Keys: Furnish four (4) each to the Owner.

B. Fuses: Furnish three (3) spare fuses of each type and rating installed to the Owner.

C. Fuse Pullers: Furnish one (1) fuse puller to the Owner.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of Section 26 05 00.

B. Deliver in 60-inch maximum width shipping splits, individually wrapped for protection, and mounted on shipping skids.

C. Store and protect products under provisions of Section 26 05 00.

D. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from fumes, dirt, water, construction debris, traffic, and physical damage.

E. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage to motor control center components, enclosure, and finish.

1.7 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Section 26 05 00.

B. Include spare parts data listing; source and current prices of replacement parts and supplies; and recommended maintenance procedures and intervals.

PART 2 - PRODUCTS

2.1 MANUAL MOTOR STARTERS MS-# AND SWITCHES MX-#

A. Acceptable Manufacturers:

1. Square D 2500 Series
2. Eaton MS Series
3. ABB
4. Siemens SMF / MMS Series

B. Manual Motor Starter: NEMA ICS 2; AC general-purpose Class A manually operated non-reversing full-voltage controller for induction motors rated in horsepower, with overload relay, and toggle operator.

C. Fractional Horsepower Manual Starter: NEMA ICS 2; AC general-purpose Class A manually operated, full-voltage controller for fractional horsepower induction motors, with thermal overload unit, and toggle operator.

D. Motor Starting Switch: NEMA ICS 2; AC general-purpose Class A manually operated, full-voltage controller for fractional horsepower induction motors, without thermal overload unit, and toggle operator.

E. Enclosure: NEMA ICS 6; Type 1.

2.2 MAGNETIC MOTOR STARTERS

A. Acceptable Manufacturers:

1. Square D
2. Eaton
3. ABB
4. Siemens
5. Franklin Control

B. Magnetic Motor Starters: NEMA ICS 2; AC general-purpose Class A magnetic controller for induction motors rated in horsepower.

C. Full Voltage Starting: Non-reversing type, unless otherwise indicated.

D. Coil Operating Voltage: 120 volts, 60 Hertz, obtained from integral control power transformer of sufficient capacity to operate connected pilot, indicating, and control devices, plus 100% spare capacity.

E. Size: NEMA ICS 2; size as shown on the drawings.

F. Overload Relay:

1. Overload Relay: Ambient-compensated type with inverse-time-current characteristic and NEMA ICS 2, Class 10 tripping characteristic. Provide with heaters or sensors in each phase matched to nameplate full-load current of specific motor to which they connect and with appropriate adjustment for duty cycle.

G. Enclosure: NEMA ICS 6; Type 1.

H. Combination Motor Starters: Combine motor starters with disconnect switch in common enclosure. Provide with disconnecting means as indicated on drawings.

I. Auxiliary Contacts: NEMA ICS 2; two normally open, field convertible contacts in addition to seal-in contact.

J. Indicating Lights: NEMA ICS 2; RUN: red in front cover.

K. Selector Switches: NEMA ICS 2; HAND/OFF/AUTO, in front cover.

L. Relays: NEMA ICS 2; .

M. Control Power Transformers: 120 volt fused secondary, fused primary, minimum VA as scheduled:

1. Size 1 - 100 VA
2. Size 2 - 100 VA
3. Size 3 - 150 VA

4. Size 4 - 300 VA
5. Size 5 - 300 VA
6. Size 6 - 300 VA

N. Provide phase loss protection relay with contacts to de-energize the starter for each starter serving motors 5 HP or greater.

2.3 ACCESSORIES

A. Provide REQUIRED accessories as described below. Provide SCHEDULED accessories when listed with plan schedules. Refer to plan schedules for additional requirements.

B. Transformer Disconnect Lockable Hasp: Provide circuit breakers, fused switches, and disconnects serving transformers with a lockable padlock hasp capable of being locked in the open/closed position. REQUIRED

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install motor control equipment in accordance with manufacturer's instructions on concrete bases.

B. Install fuses in fusible switches.

C. Select and install heater elements in motor starters to match installed motor characteristics.

D. Set field-adjustable switches and circuit-breaker trip ranges.

E. Motor Data: Provide neatly typed label inside each motor starter enclosure door identifying motor served, nameplate horsepower, full load amperes, code letter, service factor, and voltage/phase rating.

F. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.

END OF SECTION 26 24 19

SECTION 26 27 26 - WIRING DEVICES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Device plates and box covers

B. Receptacles (REC-#)

C. Countertop and furniture receptacle assemblies (REC-#)

D. Floor boxes and floor box with service fitting (FB-#)

E. Poke-through fittings (PT-#)

F. Pendant cord/connector devices

1.2 QUALITY ASSURANCE

A. Provide similar devices from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in the Electrical Code, by a testing agency to Authorities Having Jurisdiction and marked for intended use.

C. Comply with the Electrical Code.

1.3 REFERENCES

A. DSCC W-C-896F - General Specification for Electrical Power Connector

B. FS W-C-596 - Electrical Power Connector, Plug, Receptacle, and Cable Outlet

C. NEMA WD 1 - General Color Requirements for Wiring Devices

D. NEMA WD 6 - Wiring Devices - Dimensional Requirements

E. NFPA 70 - National Electrical Code (NEC)

F. UL 498 - Standard for Attachment Plugs and Receptacles

G. UL 943 - Standard for Ground Fault Circuit Interrupters

1.4 COORDINATION

A. Receptacles for Owner Furnished Equipment: Match plug configurations.

B. Cord and Plug Sets: Match equipment requirements.

C. Coordinate installation of receptacle assemblies in countertops and furniture with the Contractor providing the countertop or furniture. Contractor shall coordinate penetrations and conduit routing in countertops and furniture with drawings and other obstacles below the installation surface.

PART 2 - PRODUCTS

2.1 DEVICE COLOR

A. All switch, receptacle, and outlet colors shall be verified with Architect, unless indicated otherwise.

2.2 COVERPLATES

A. All switches, receptacles, and outlets shall be complete with the following:

1. Unbreakable thermoplastic/thermoset plastic and match device color coverplates in finished spaces where walls are finished.
2. Decorator Grade - Public: Decorator thermoset plastic and match device color wallplates in public finished spaces where walls are finished.

    a. Manufacturer:

        1) Leviton Decora
        2) Hubbell Decorator
        3) Cooper Decorator
        4) or approved equal

3. #302 stainless steel coverplates in unfinished spaces for flush boxes.
4. Galvanized steel coverplates in unfinished spaces for surface mounted boxes.

B. Where several devices are ganged together, the coverplate shall be of the ganged style for the number of devices used.

C. Install nameplate identification as indicated in Section 26 05 53.

D. Plate securing screws shall be metal with head color matching the wall plate finish.

2.3 RECEPTACLES

A. Refer to Electrical Symbols List for device type.

B. Devices that are shaded on the drawings shall be red.

C. REC-DUP: NEMA 5-20R Duplex Receptacle:

1. Standard Grade: 125-volt, 20 amp, 3-wire grounding type with impact resistant thermoplastic face and steel back strap.

    a. Manufacturers:

        1) Hubbell 5352A
        2) Leviton, 5362-S
        3) Pass & Seymour 5362
        4) Cooper 5352

2. Heavy Duty: 125-volt, 20 amp, 3-wire grounding type heavy duty industrial grade with impact resistant thermoplastic face and one-piece brass back strap with integral ground contacts.

   a. Manufacturers:

      1) Hubbell 5362
      2) Leviton 5362
      3) Pass & Seymour 5362A
      4) Cooper AH5362

D. REC-DUP-GFI: NEMA 5-20R Ground Fault Duplex Receptacle:

1. Standard Grade: 125-volt, 20 amp, 3-wire grounding type with test and reset buttons in impact resistant thermoplastic face.

   a. Device shall perform self-test of GFCI circuitry in accordance with UL 943.
   b. Manufacturers:

      1) Hubbell GF20L
      2) Leviton GFNT2
      3) Pass & Seymour 2097
      4) Cooper SGF20

E. REC-DUP-GFI-R: Remote Ground Fault Device:

1. Ground fault device for remote downstream receptacles. 125-volt, 20 amp. Test and reset buttons in impact resistance thermoplastic face.

   a. Manufacturers:

      1) Hubbell GFBF20
      2) Leviton 6895
      3) Pass & Seymour 2085
      4) Cooper VGFD20

F. REC-DUP-WP: NEMA 5-20R Weatherproof Ground Fault Duplex Receptacle:

1. 125-volt, 20 amp, 3-wire grounding type with test and reset buttons in impact resistant thermoplastic face, weather resistant WR listed. Provide extra-duty NEMA 3R rated while-in-use cast aluminum cover.
2. Device shall perform self-test of GFCI circuitry in accordance with UL 943.

   a. Manufacturers:

      1) Hubbell:

         a) GFTWRST20 with aluminum housing WP826
         b) GFCI type devices are not allowed. Contractor may substitute an alternative manufacturer when Hubbell is the basis of submittal for all other wiring devices.

      2) Leviton GFWT2 with aluminum housing M5979
      3) Pass & Seymour 2097TRWR with aluminum housing WIUCAST1
      4) Cooper WRSGF20 with aluminum housing WIUMV-1

G. REC-USB: NEMA 5-20R Receptacle with USB Charger:

1. Standard Grade Type A USB: 125-volt, 20-amp, tamper resistant, 3-wire grounding type with impact resistant thermoplastic face. Type A USB charging rated at 5VDC 3.0A minimum. Mounted in double gang backbox.

a. Manufacturers:

1) Hubbell USB20X2
2) Pass & Seymour TR5362USB
3) Cooper TR7766

2. Standard Grade Type C USB: 125-volt, 20-amp, tamper resistant, 3-wire grounding type with impact resistant thermoplastic face. One Type A USB charging rated at 5VDC 3.0A minimum. One Type C USB charging rated at 5VDC 5.0A. Mounted in double gang backbox.

a. Manufacturers:

1) Hubbell USB USB20C5

H. REC-SIM-520R: NEMA 5-20R Simplex Receptacle:

1. 125-volt, 20 amp, 3-wire grounding type with impact resistant thermoplastic face.

a. Manufacturers:

1) Hubbell HBL5361
2) Leviton 5361
3) Pass & Seymour 5361
4) Cooper 5361

I. REC-SIM-530R: NEMA 5-30R Simplex Receptacle:

1. 125-volt, 30 amp, 3-wire grounding type, phenolic face.

a. Manufacturers:

1) Hubbell HBL9308
2) Leviton 5371
3) Pass & Seymour 3802
4) Cooper 5716N

J. REC-SIM-550R: NEMA 5-50R Simplex Receptacle:

1. 125-volt, 50 amp, 3-wire grounding type, phenolic face.

a. Manufacturers:

1) Hubbell HBL9360
2) Cooper 1253

K. REC-SIM-620R: NEMA 6-20R Simplex Receptacle:

1. 250-volt, 20 amp, 2-pole, 3-wire grounding type with thermoplastic face.

a. Manufacturers:

1) Hubbell HBL5461
2) Leviton 5461

3) Pass & Seymour 5871
4) Cooper 5461

L. REC-SIM-630R: NEMA 6-30R Simplex Receptacle:

1. 250-volt, 30 amp, 2-pole, 3-wire grounding type with thermoplastic face.

a. Manufacturers:

1) Hubbell HBL9330
2) Leviton 5372
3) Pass & Seymour 3801
4) Cooper 5700N

M. REC-SIM-650R: NEMA 6-50R Simplex Receptacle:

1. 250-volt, 50 amp, 2-pole, 3-wire grounding type with thermoplastic face.

a. Manufacturers:

1) Hubbell HBL9367
2) Leviton 5374
3) Pass & Seymour 3804
4) Cooper 5709N

N. REC-SIM-1420R: NEMA 14-20R Simplex Receptacle:

1. 125/250-volt, 20 amp, 3-pole, 4-wire grounding type with thermoplastic face.

a. Manufacturers:

1) Hubbell HBL8410
2) Pass & Seymour 3820
3) Cooper 5759

O. REC-SIM-1430R: NEMA 14-30R Simplex Receptacle:

1. 125/250-volt, 30 amp, 3-pole, 4-wire grounding type with thermoplastic face. Flush mounted at +24 AFF.

a. Manufacturers:

1) Hubbell HBL9430A
2) Leviton 278
3) Pass & Seymour 3864
4) Cooper 5744N

P. REC-SIM-1520R: NEMA 15-20R Simplex Receptacle:

1. 250-volt, 20 amp, 3-phase, 3-pole, 4-wire grounding type with thermoplastic face.

a. Manufacturers:

1) Hubbell HBL8420
2) Leviton
3) Pass & Seymour
4) Cooper

Q. REC-SIM-1530R: NEMA 15-30R Simplex Receptacle:

1. 250-volt, 30 amp, 3-phase, 3-pole, 4-wire grounding type with thermoplastic face.

a. Manufacturers:

1) Hubbell HBL8430A
2) Leviton 8430
3) Pass & Seymour 5740
4) Cooper 8430N

R. REC-SIM-1550R: NEMA 15-50R Simplex Receptacle:

1. 250-volt, 50 amp, 3-phase, 3-pole, 4-wire grounding type with thermoplastic face.

a. Manufacturers:

1) Hubbell HBL8450A
2) Leviton 8450
3) Pass & Seymour 5750
4) Cooper 8450N

S. REC-SIM-1560R: NEMA 15-60R Simplex Receptacle:

1. 250-volt, 60 amp, 3-phase, 3-pole, 4-wire grounding type with thermoplastic face.

a. Manufacturers:

1) Hubbell HBL9460A
2) Pass & Seymour 5760
3) Cooper 8460N

T. REC-SIM-L520R: NEMA L5-20R Simplex Receptacle, Locking Type:

1. 125-volt, 20 amp, 2-pole, 3-wire grounding type with impact resistant thermoplastic face.

a. Manufacturers:

1) Hubbell
2) Leviton
3) Pass & Seymour L520
4) Cooper CWL520R

U. REC-SIM-L530R: NEMA L5-30R Simplex Receptacle Locking Type:

1. 125-volt, 30 amp, 2-pole, 3-wire grounding type with impact resistant thermoplastic face.

a. Manufacturers:

1) Hubbell
2) Leviton
3) Pass & Seymour L530
4) Cooper CWL530R

V. REC-SIM-L620R: NEMA L6-20R Locking Type Simplex Receptacle:

1. 250-volt, 20 amp, 2-pole, 3-wire grounding type with thermoplastic face.

a. Manufacturers:

1) Hubbell HBL2320
2) Leviton 2320
3) Pass & Seymour L620R
4) Cooper CWL620R

W. REC-SIM-L630R: NEMA L6-30R Locking Type Simplex Receptacle:

1. 250-volt, 30 amp, 2-pole, 3-wire grounding type with thermoplastic face.

a. Manufacturers:

1) Hubbell HBL2620
2) Leviton 2620
3) Pass & Seymour L630R
4) Cooper CWL630R

X. REC-SIM-L720R: NEMA L7-20R Locking Type Simplex Receptacle:

1. 277-volt, 20 amp, 2-pole, 3-wire grounding type with thermoplastic face.

a. Manufacturers:

1) Hubbell HBL2330
2) Leviton 2330
3) Pass & Seymour L720R
4) Cooper CWL720R.

Y. REC-SIM-L730R: NEMA L7-30R Locking Type Simplex Receptacle:

1. 277-volt, 30 amp, 2-pole, 3-wire grounding type with thermoplastic face.

a. Manufacturers:

1) Hubbell HBL2630
2) Leviton 2630
3) Pass & Seymour L730R
4) Cooper CWL730R

Z. REC-SIM-L1420R: NEMA L14-20R Locking Type Simplex Receptacle:

1. 125/250-volt, 20 amp, 3-pole, 4-wire grounding type with thermoplastic face.

a. Manufacturers:

1) Hubbell HBL 2410
2) Pass & Seymour L1420
3) Cooper CWL1420R

AA. REC-SIM-L1430R: NEMA L14-30R Locking Type Simplex Receptacle:

1. 125/250-volt, 30 amp, 3-pole, 4-wire grounding type with thermoplastic face.

a. Manufacturers:

1) Hubbell HBL 2710
2) Leviton 2710
3) Pass & Seymour L1430R
4) Cooper CWL1430R

BB. REC-SIM-L1520R: NEMA L15-20R Locking Type Simplex Receptacle:

1. 250-volt, 20 amp, 3-phase, 3-pole, 4-wire grounding type with thermoplastic face.

a. Manufacturers:

1) Hubbell HBL2420
2) Leviton 2420
3) Pass & Seymour L1520R
4) Cooper CWL1520R

CC. REC-SIM-L1530R: NEMA L15-30R Locking Type Simplex Receptacle:

1. 250-volt, 30 amp, 3-phase, 3-pole, 4-wire grounding type with thermoplastic face.

a. Manufacturers:

1) Hubbell HBL2720
2) Leviton 2720
3) Pass & Seymour L1530R
4) Cooper CWL1530R

DD. REC-SIM-L1620R: NEMA L16-20R Locking Type Simplex Receptacle:

1. 480-volt, 20 amp, 3-pole, 4-wire grounding type with thermoplastic face.

a. Manufacturers:

1) Hubbell HBL2431
2) Pass & Seymour L1620R
3) Cooper CWL1620R

EE. REC-SIM-L1630R: NEMA L16-30R Locking Type Simplex Receptacle:

1. 480-volt, 30 amp, 3-pole, 4-wire grounding type with thermoplastic face.

a. Manufacturers:

1) Hubbell HBL2730
2) Leviton 2730
3) Pass & Seymour L1630R
4) Cooper CWL1630R

FF. REC-SIM-L2120R: NEMA L21-20R Locking Type Simplex Receptacle:

1. 120/208Y 3 phase 20-amp 5 wire grounding type.

a. Manufacturers:

1) Hubbell HBL2510
2) Cooper CWL2120R
3) Pass & Seymour L2120R

GG. REC-SIM-L2130R: NEMA L21-30R Locking Type Simplex Receptacle:

1. 120/208Y 3 phase 30-amp 5 wire grounding type.

a. Manufacturers:

1) Hubbell HBL2750
2) Cooper CWL2130R
3) Pass & Seymour L2130R

HH. REC-TAMP: NEMA 5-20R Tamper Resistant Duplex Receptacle:

1. Standard Grade: 125-volt, 20 amp, 3-wire grounding type with impact resistant thermoplastic face.

a. Manufacturers:

1) Hubbell BR20TR
2) Leviton TBR20
3) Pass & Seymour TR5362
4) Cooper TRBR20

2. Decorative Grade: Provide decorative style duplex tamper resistant receptacles in public spaces where walls are finished.

a. Manufacturers:

1) Hubbell DR20TR
2) Leviton TDR20
3) Pass & Seymour TR2635

II. REC-TAMP-GFI: NEMA 5-20R GFI Tamper Resistant Receptacle:

1. Standard Grade: 125-volt, 20 amp, 3-wire grounding type tamper-resistant with test and reset buttons in impact resistant thermoplastic face.

a. Device shall perform self-test of GFCI circuitry in accordance with UL 943.
b. Manufacturers:

1) Hubbell GFTR20
2) Cooper TRSGF20
3) Pass & Seymour 2097TR
4) Leviton GFTR2

JJ. REC-TAMP-QUAD: NEMA 5-20R Double Duplex Tamper Resistant Receptacle:

1. Consists of two duplex tamper resistant receptacles, double gang box, plaster ring and faceplate.

a. Manufacturers:

1) Refer to Tamper Resistant Receptacle above.

KK. REC-QUAD: NEMA 5-20R Double Duplex Receptacle:

1. Consists of two duplex receptacles, double gang box, plaster ring and faceplate.

a. Manufacturers:

1) Refer to Duplex Receptacle above.

LL. REC-QUAD-GFI: NEMA 5-20R Double Duplex GFI Receptacle:

1. Consists of two duplex GFI receptacles, double gang box, plaster ring and faceplate.

a. Manufacturers:

1) Refer to Duplex GFI Receptacle above.

MM. REC-QUAD-USB: NEMA 5-20R Double Duplex USB Receptacle:

1. Consists of two duplex USB receptacles, double gang box, plaster ring and faceplate.

a. Manufacturers:

1) Refer to USB Receptacle above.

NN. REC-QUAD-WP: NEMA 5-20R Weatherproof Ground Fault Quad Receptacle:

1. Consists of two duplex, GFI receptacles. Double gang box. Provide extra-duty NEMA 3R rated while-in-use cast aluminum cover.

a. Manufacturers:

1) Receptacle: Refer to GFCI Receptacle above.
2) Cover:

a) Intermatic WP1030MXD
b) Pass & Seymour WIUCAST2
c) Thomas & Betts Red Dot 2CKU

OO. Back wired devices shall be complete with eight holes that are screw activated with metal clamps for connection to #12 or #10 copper conductors.

PP. Side wired devices shall have four binding screws that are undercut for positive wire retention.

QQ. Ground fault circuit interrupter (GFCI) receptacles shall comply with UL 943 requiring increased surge immunity, improved corrosion resistance, improved resistance to false tripping and diagnostic indication for miswiring if the line and load conductors are reversed during installation.

RR. Integral surge suppression receptacles with integral surge suppression shall comply with the following:

1. Category A3 listed.
2. Line to ground, line to neutral, and neutral to ground modes.
3. Metal-oxide varistors with a nominal clamp level rating of 500 volts and minimum single transient pulse energy dissipation of 210 joules per mode.
4. Status indication: Light visible in the face of the device and audible alarm to indicate device is no longer active or in service.
5. Distinctive symbol on device face to denote SPD-type device.
6. Device shall be blue with stainless coverplate.
7. NEMA 5-20R duplex receptacle, 125-volt, 20 amp, 3-wire grounding type heavy duty industrial grade with impact resistant thermoplastic face and one-piece brass back strap.

a. Manufacturers:

1) Hubbell HBL5362SA
2) Leviton
3) Pass & Seymour
4) Cooper

SS. Hazardous (Classified) location receptacles shall comply with NEMA FB 11.

2.4 COUNTERTOP AND FURNITURE RECEPTACLE ASSEMBLIES

A. REC-#: Pop-up Style Receptacle Assembly Listed for Countertop Applications.

1. 125-volt, 15/20-amp, tamper resistant, 3-wire grounding type with impact resistant thermoplastic face. Two (2) NEMA 5-15R/5-20R, with both simplex devices on same face or opposite face of assembly, gasketed countertop enclosure, UL 948 section 146 spill test. Architect to select finish from standard factory options. Device(s) installation, orientation, and finish shall be coordinated with Architect/Engineer prior to installation.
2. Product Specific Coordination:

    a. The Contractor shall provide provisions as required to maintain the product listing. Refer to the manufacturer's instructions for a complete list of product specific installation requirements.
    b. Hubbell: Provide GFCI circuit breaker for overcurrent protection device serving branch circuit.
    c. Lew Electric: Provide a REC-DUP-GFI in the cabinet cavity below the countertop for the device to plug into. Coordinate installation of the duplex device with the space available in the below countertop cabinet.
    d. Branch Circuit: Provide a 15A/1P circuit breaker for 15 amp rated devices served by a dedicated branch circuit.

3. Manufacturers:

    a. Hubbell RCT200
    b. Lew Electric PUR20

B. REC-#: Pop-up Style Receptacle Assembly Listed for Furniture Installation.

1. 125-volt, 15/20-amp, tamper resistant, 3-wire grounding type with impact resistant thermoplastic face. Two (2) NEMA 5-15R/5-20R, with both simplex devices on same face of assembly. Two (2) Type A USB charging rated at 5VDC 3.0A minimum. Mounted in 5"x5"x5" maximum pop-up enclosure. Architect to select finish from standard factory options.
2. Device(s) installation, orientation, and finish shall be coordinated with Architect/Engineer prior to installation.
3. Product Specific Coordination:

    a. The Contractor shall provide provisions as required to maintain the product listing. Refer to the manufacturer's instructions for a complete list of product specific installation requirements.
    b. Hubbell: Provide a REC-DUP-GFI in the cabinet cavity below the countertop for the device to plug into. Coordinate installation of the duplex device with the space available in the below countertop cabinet.
    c. Lew Electric: Provide gfi circuit breaker for overcurrent protection device serving branch circuit.
    d. Wiremold: Provide GFCI circuit breaker for overcurrent protection device serving branch circuit.
    e. Branch Circuit: Provide a 15A/1P circuit breaker for 15 amp rated devices served by a dedicated branch circuit.

4. Manufacturers:

    a. Hubbell WSBUSB2X2
    b. Wiremold DQFPUST
    c. Lew Electric PUFP-CT-2USB

C. REC-#: Modular Furniture Power System Listed for Furniture Installation.

1. 125-volt, 15/20-amp, tamper resistant, 3-wire grounding type with impact resistant thermoplastic face. Three (3) NEMA 5-15R/5-20R, with both simplex devices on same face of assembly. One (1) combination Type A/Type C USB charging rated at 5VDC 3.0A minimum. Integral circuit breaker. First unit includes 10ft plug-and-cord. Daisy-chained units including a 3ft cord between devices. Refer to plans for quantity of devices required. UL 962A Spill/Splash rated. Color selection by architect based on standard factory options.
2. Mounting: recessed in surface hardware
3. Device(s) installation, orientation, and finish shall be coordinated with Architect/Engineer prior to installation.
4. Product Specific Coordination:

    a. The Contractor shall provide provisions as required to maintain the product listing. Refer to the manufacturer's instructions for a complete list of product specific installation requirements.
    b. Branch Circuit: Provide a 15A/1P circuit breaker for 15 amp rated devices served by a dedicated branch circuit.

5. Manufacturers:

    a. Legrand Modpower Series

2.5 FLOOR BOXES

A. Cover Color and Style: Verify with Architect from manufacturer standard options ; from custom options selected by Architect.

B. Refer to Technology drawings for voice/data, Audio/Video outlet, and coordination requirements.

C. Floor Boxes Housing Material Based on Cast-in-Place Floor Type:

1. Slab on Grade: Cast Iron or listed for slab on grade with special kit, coating ,or equivalent; corrosion resistant.
2. Elevated Slab: stamped steel,
3. Raised Access Floor, Cast-in-Place, or Access Floor Panels: Stamped steel.
4. Wood Floor, not Cast-in-Place: Stamped steel and rated for wood floor application.

D. FB-#: Concealed Center Compartment:

1. Floor Box, flush-mounted hinged cover, square/rectangular center service area with closed while-in-use cover and cable egress doors in cover, provide complete with appropriate outlet cover plates and hardware. For use with 4-inch minimum concrete pour floors, fully adjustable, UL 514 scrub water listed.
2. Gang / Outlet Descriptions:

    a. 125 Volt, 20 amp, NEMA 5-20R duplex receptacle with 3/4-inch conduit.
    b. Voice/Data outlet with 3/4-inch conduit. Refer to Technology drawings for additional information.
    c. Audio/Visual outlet with 3/4-inch conduit. Refer to Technology drawings for additional information.
    d. Spare with 3/4-inch conduit.

3. Manufacturers:

    a. Hubbell CFB Series
    b. Legrand Wiremold RFB Series
    c. ABB Steel City 664/665/667 Series

4. Installation: Group route raceway conduits under slab on grade or in ceiling space below to nearest wall or as shown on plans. Provide provisions to core drill elevated floors and route conduits to ceiling space of associated floor box. Provide hub reducers when applicable.

E. FB-#: Concealed Center Compartment (Access Floor):

1. Floor Box, access floor type, square/rectangular flush-mounted hinged cover, center service area with closed while-in-use cover and sable egress doors in cover, provide complete with appropriate outlet cover plates and hardware, UL 514 scrub water listed. For use in access floors systems ¾" – 2" thick.
2. Gang / Outlet Descriptions:

   a. 125 Volt, 20 amp, NEMA 5-20R duplex receptacle with 3/4-inch conduit.
   b. Voice/Data outlet with 3/4 -inch conduit. Refer to Technology drawings for additional information.
   c. Audio/Visual outlet with 3/4 -inch conduit. Refer to Technology drawings for additional information.
   d. Spare with 3/4- inch conduit.

3. Manufacturers:

   a. Hubbell AFB Series
   b. Legrand Wiremold Evolution Series
   c. ABB Steel City AFM Series

4. Installation: Group route raceway conduits under finished access floor to nearest wall or as shown on plans. Provide hub reducers when applicable.

F. FB-#: Round Flush with Finished Floor:

1. Floor Box, round, round flush-mounted hinged cover with flange, provide complete with appropriate outlet cover plates and hardware, for use with X-inch minimum concrete pour floors, fully adjustable.
2. Gang / Outlet Descriptions:

   a. 125 Volt, 20 amp, NEMA 5-20R duplex receptacle with 3/4-inch conduit.
   b. Voice/Data outlet with 3/4-inch conduit.
   c. Audio/Visual outlet with 3/4-inch conduit.
   d. Power furniture/equipment feed with flexible whip and 3/4-inch conduit.
   e. Voice/Data furniture/equipment feed with flexible whip and 3/4-inch conduit.
   f. Audio/Visual furniture/equipment feed with flexible whip and 3/4-inch conduit.
   g. Spare with 3/4- inch conduit.
   h. Refer to Technology drawings for additional information related to voice/data and audio/visual outlet requirements.

3. Manufacturers:

   a. Cast:

      1) Hubbell 2503 Series
      2) Legrand Wiremold 880 Series
      3) ABB Steel City 600 Series

   b. Stamped Steel:

      1) Hubbell B2527 Series
      2) Legrand Wiremold 880 Series
      3) ABB Steel City 68 Series

c. Non-Metallic PVC:

1) Hubbell PFB1 Series
2) Legrand Wiremold 880 Series
3) ABB Steel City 68 HP Series

4. Installation: Group route raceway conduits under slab on grade or in elevated slab to nearest wall. Route conduits to nearest wall or as shown on drawings. Provide hub reducers when applicable.

G. FB-#: Square or Rectangular (Standard):

1. Floor Box, square or rectangular, square/rectangular flush-mounted hinged cover with flange, provide complete with appropriate outlet cover plates and hardware, for use with X-inch minimum concrete pour floors, fully adjustable.
2. Gang / Outlet Descriptions:

a. 125 Volt, 20 amp, NEMA 5-20R duplex receptacle with 3/4-inch conduit.
b. Voice/Data outlet with 3/4-inch conduit.
c. Audio/Visual outlet with 3/4-inch conduit.
d. Power furniture/equipment feed with flexible whip and 3/4-inch conduit.
e. Voice/Data furniture/equipment feed with flexible whip and 3/4-inch conduit.
f. Audio/Visual furniture/equipment feed with flexible whip and 3/4-inch conduit.
g. Spare with 3/4- inch conduit.
h. Refer to Technology drawings for additional information related to voice/data and audio/visual outlet requirements.

3. Manufacturers:

a. Cast:

1) Hubbell B### Series
2) Legrand Wiremold 880 Series
3) ABB Steel City 640 / 840 Series

b. Stamped Steel:

1) Hubbell 242# Series
2) Legrand Wiremold 880 Series
3) ABB Steel City 740 Series

c. Non-Metallic PVC:

1) Hubbell
2) Legrand Wiremold 880 Series
3) ABB Steel City 640 Series

4. Installation: Group route raceway conduits under slab on grade or in elevated slab to nearest wall. Route conduits to nearest wall or as shown on drawings. Provide hub reducers when applicable.

H. FB-#: Square or Rectangular (Shallow):

1. Floor Box, square or rectangular, square/rectangular flush-mounted hinged cover with flange, provide complete with appropriate outlet cover plates and hardware, for use with X-inch minimum concrete pour floors, fully adjustable.
2. Gang / Outlet Descriptions:

a. 125 Volt, 20 amp, NEMA 5-20R duplex receptacle with 3/4-inch conduit.
b. Voice/Data outlet with 3/4-inch conduit.
c. Audio/Visual outlet with 3/4-inch conduit.
d. Power furniture/equipment feed with flexible whip and 3/4-inch conduit.

e. Voice/Data furniture/equipment feed with flexible whip and 3/4-inch conduit.
f. Audio/Visual furniture/equipment feed with flexible whip and 3/4-inch conduit.
g. Spare with 3/4- inch conduit.
h. Refer to Technology drawings for additional information related to voice/data and audio/visual outlet requirements.

3. Manufacturers:

a. Cast:

1) Hubbell B### Series
2) Legrand Wiremold 880 Series
3) ABB Steel City 640 / 840 Series

b. Stamped Steel:

1) Hubbell B243# Series
2) Legrand Wiremold 880 Series
3) ABB Steel City 740 Series

4. Installation: Group route raceway conduits under slab on grade or in elevated slab to nearest wall. Route conduits to nearest wall or as shown on drawings. Provide hub reducers when applicable.

2.6 POKE-THROUGH FITTINGS

A. Cover Color and Style: Verify with Architect from manufacturer standard options.

B. Refer to Technology drawings for voice/data, Audio/Video outlet, and coordination requirements.

C. UL listed as fire-rated poke-through device for 1, 2, 4-hour rated floors: include fire stops and smoke barriers in through-floor component. UL514A listed for scrub locations.

D. Terminate in 4-inch square by 2-1/2-inch deep junction box.

E. Suitable for installation with a floor thickness of 2-1/4 to 7 inches.

F. PT-#: 3" Fire Rated Poke-Through:

1. Semi-flush mounted, hinged covers, for use with 3-inch core holes, provide complete with appropriate outlet coverplates and hardware. UL 514 scrub rated listed.
2. Gang / Outlet Descriptions, route conduit in ceiling space of lower level. Provide provisions to core drill floor to route power circuits to panel on same floor as poke through. Route low voltage raceways[to scheduled technology room][to cable tray][to cable management system]:

a. 125 Volt, 20 amp, NEMA 5-20R duplex receptacle.
b. Voice/Data outlet.
c. Audio/Visual outlet.
d. Power furniture/equipment feed with flexible whip.
e. Voice/Data furniture/equipment feed with flexible whip.
f. Audio/Visual furniture/equipment feed with flexible whip.
g. Conduit Raceway (in ceiling space below floor):

1) Power: 3/4-inch conduit.
2) Voice/Data: 1-1/4-inch conduit.
3) Audio/Visual: 2-inch conduit.

h. Refer to Technology drawings for additional information related to voice/data and audio/visual outlet requirements.

3. Manufacturers:

   1) Hubbell PT2X2
   2) Wiremold
   3) Thomas & Betts

G. PT-#: 4" Fire Rated Poke-Through:

1. Semi-flush mounted, hinged covers, for use with 4-inch core holes, provide complete with appropriate outlet coverplates and hardware. UL 514 scrub rated listed.
2. Gang / Outlet Descriptions, route conduit in ceiling space of lower level. Provide provisions to core drill floor to route power circuits to panel on same floor as poke through. Route low voltage raceways to cable tray:

   a. 125 Volt, 20 amp, NEMA 5-20R duplex receptacle.
   b. Voice/Data outlet.
   c. Audio/Visual outlet.
   d. Power furniture/equipment feed with flexible whip.
   e. Voice/Data furniture/equipment feed with flexible whip.
   f. Audio/Visual furniture/equipment feed with flexible whip.
   g. Spare.
   h. Conduit Raceway (in ceiling space below floor):

      1) Power: 3/4-inch conduit.
      2) Voice/Data: 1-1/4-inch conduit.
      3) Audio/Visual: 2-inch conduit.

   i. Refer to Technology drawings for additional information related to voice/data and audio/visual outlet requirements.

3. Manufacturers:

   a. Hubbell SystemOne Series
   b. Legrand Wiremold 4RF/RC Series
   c. ABB Steel City FPT4 Series

2.7 PENDANT CORD/CONNECTOR DEVICES

A. Description: Matching, locking type plug and receptacle body connector, NEMA WD 6, Configurations L5-20P and L5-20R, heavy-duty grade or refer to Details as shown on drawings.

1. Body: Nylon with screw-open cable gripping jaws and provisions for attaching external cable grip.

B. External Cable Grip: Woven wire mesh type made of high strength galvanized steel wire stand, matched to cable diameter, and with attachment provision designed for corresponding connector.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install convenience receptacles at elevations indicated in the General Installation Notes on the contract drawings.

B. Install specific-use receptacles at heights shown on the contract drawings. Install devices level, plumb, and square with building lines. Coordinate installation of adjacent devices of separate systems with common mounting heights, including lighting, power, systems, technology, and temperature control device rough-ins.

C. Ground Fault Protection: Provide ground fault protection for all branch circuit breakers serving 120/208 receptacle outlets rated 21 - 50 amps single phase and 21-100 amps three phase in the following locations, as shown on drawings, or required by adopted code:

1. Bathrooms, locker rooms, shower rooms
2. Kitchens
3. Rooftops
4. Interior/Exterior locations subject to damp/wet conditions
5. When located within 6 feet of sinks, bathtubs, and shower stalls
6. Garages, accessory buildings, service bays

D. Tamper Resistant Protection: Provide tamper resistant protection for all 15 / 20-amp 120/208 straight blade wiring devices in the following locations, as shown on the drawings, or required by adopted code.

1. Dwelling units, dormitory units
2. Guest rooms and suites
3. Childcare, preschool, elementary, middle, high school, educational facilities
4. Business Office: Corridors, waiting rooms, common areas
5. Public Buildings: Corridors, waiting rooms, common areas
6. Assisted living

E. Drill opening for poke-through fitting installation in accordance with manufacturer's instructions. This Contractor is responsible for taking any measures required to ensure no conduits or other services are damaged. This may include X-ray or similar non-destructive means.

F. Install receptacles vertically with ground slot up or where indicated on the drawings, horizontally with ground slot to the left.

G. Install decorative plates on switch, receptacle, and blank outlets in finished areas, using jumbo size plates for outlets installed in masonry walls.

H. Install galvanized steel plates on outlet boxes and junction boxes in unfinished areas, above accessible ceilings, and on surface-mounted outlets.

I. Install devices and wall plates flush and level.

J. Install nameplate identification to receptacle cover plates indicated. Identification shall identify panel name and circuit number. Refer to Specification Section 26 05 53 - Electrical Identification.

K. Test receptacles for proper polarity, ground continuity and compliance with requirements.

END OF SECTION 26 27 26

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SECTION 26 28 13 - FUSES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Fuses

B. Spare Fuse Cabinet

1.2 REFERENCES

A. UL 198C - High-Interrupting Capacity Fuses; Current Limiting Types

B. UL 198E - Class R Fuses

C. FS W-F-870 - Fuseholders (For Plug and Enclosed Cartridge Fuses)

D. NEMA FU 1 - Low Voltage Cartridge Fuses

E. NFPA 70 - National Electrical Code (NEC)

1.3 EXTRA MATERIALS

A. Provide two fuse pullers.

B. Provide three of each size and type of fuse installed.

1.4 PROJECT CONDITIONS

A. Where ambient temperature to which fuses are directly exposed is less than 40°F or more than 100°F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

PART 2 - PRODUCTS

2.1 MANUFACTURERS - FUSES

A. Bussman, Division of Eaton

B. Edison Fuse, Division of Cooper Industries

C. Mersen

D. Littelfuse Inc

2.2 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. Fuses with ratings larger than 600 amperes: Class L (time delay), unless otherwise noted on the drawings.

D. Fuses with ratings larger than 200 amperes but equal to or less than 600 amperes: Class RK-1 (time delay), unless otherwise noted on the drawings.

E. Fuses with ratings less than or equal to 200 amperes (not including control transformer fuses): Class RK-5, unless otherwise noted on the drawings.

F. Control transformer fuses: Class CC (time delay).

G. Fuses for packaged equipment: Size and type as recommended by equipment manufacturer.

2.3 SPARE FUSE CABINET

A. Cabinet: Wall-mounted, 0.05-inch- thick steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.

1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.
2. Finish: Gray, baked enamel.
3. Identification: "SPARE FUSES" in 1-1/2-inch- high letters on exterior of door.
4. Fuse Pullers: For each size of fuse.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install fuses where indicated on the drawings and specifications.

B. Install fuses in accordance with manufacturer's instruction.

C. Install fuses in packaged equipment as required by equipment manufacturer.

D. Install fuse with label oriented such that manufacturer, type, and size are easily read.

E. Install spare fuse cabinet in the Main Electrical Room.

END OF SECTION 26 28 13

SECTION 26 28 16 - DISCONNECT SWITCHES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Fusible switches

B. Non-fusible switches

C. Molded case circuit switches

D. Molded case switches

E. Motor disconnect switch

F. Mechanically interlocked disconnect

G. Elevator Service Disconnect Switch

H. Enclosures

1.2 RELATED SECTIONS AND WORK

A. Refer to the Disconnect and Starter Schedule for rating and configuration.

1.3 REFERENCES

A. NEMA KS 1 - Enclosed Switches

1.4 SUBMITTALS

A. Submit product data under provisions of Section 26 05 00.

B. Product Data: For each type of enclosed switch, circuit breakers, accessory and component indicated, include dimensions, weights, and manufacturer's technical data on features, performance, and ratings.

C. Electrical Characteristics: For each type of enclosed switch, enclosure types, current and voltage ratings, short-circuit current ratings, UL listing for series rating of installed devices, features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

1.5 COORDINATION

A. Coordinate layout and installation of switches, circuit breakers, and components with other construction, including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 - PRODUCTS

2.1 FUSIBLE AND NON-FUSIBLE SWITCHES

A. Acceptable Manufacturers:

1. Square D 3110 Series
2. ABB TH Series
3. Siemens HNF / HF Series

B. FDS-#; Fusible Switch Assemblies: NEMA KS 1; Type heavy duty, quick-make, quick-break, load interrupter enclosed knife switch with externally operable handle interlocked to prevent opening front cover with switch in ON position. Handle lockable in OFF position. Fuse Clips: Class 'R' fuse clips only, unless indicated otherwise on the drawings.

C. DS-#; Non-fusible Switch Assemblies: NEMA KS 1; Type heavy duty, quick-make, quick-break, load interrupter enclosed knife switch with externally operable handle interlocked to prevent opening front cover with switch in ON position. Handle lockable in OFF position.

D. Enclosures: Type as indicated on the disconnect schedule.

E. Accessories: As indicated on the disconnect schedule.

2.2 MOLDED CASE CIRCUIT BREAKERS AND SWITCHES

A. Acceptable Manufacturers:

1. Square D
2. ABB
3. Siemens

B. CB-#; Molded Case Circuit Breaker: NEMA AB 1, with interrupting capacity to meet available fault currents.

1. Thermal Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
2. Adjustable Instantaneous Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip settings.
3. Electronic Trip Unit Circuit Breakers: RMS sensing; field-replaceable rating plug; with the following field-adjustable settings:

    a. Instantaneous trip.
    b. Long- and short-time pickup levels.
    c. Long- and short-time adjustments.
    d. Ground-fault pickup level, time delay, and I2t responses.

4. Current Limiting Circuit Breakers: Frame sizes 400 A and smaller and let-through ratings less than NEMA FU 1, RK-5.

C. CB-#; Molded Case Switches: Molded case circuit breaker with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.

D. Accessories: As indicated on the disconnect schedule.

2.3 MOTOR DISCONNECT SWITCH

A. Acceptable Manufacturers:

1. Square D 3110 Series
2. ABB ML Series
3. Siemens LBR Series

B. MD-#; Rotary Switch Assemblies: Rated for making and breaking loads, rotary type enclosed switch with externally operable handle interlocked to prevent opening front cover with switch in ON position. Handle lockable in OFF position.

C. Enclosures: Type as indicated on the Disconnect Schedule.

D. Ground lug connection provided in enclosure.

E. Accessories: As indicated on the Disconnect Schedule.

F. Listed UL 508 suitable for motor control.

2.4 MECHANICALLY INTERLOCKED DISCONNECT

A. Acceptable Manufacturers:

1. Disconnect

a. Square D 3110 Series
b. ABB TH Series
c. Siemens HF Series

2. Receptacle

a. Crouse-Hinds Arktite
b. Appleton Powertite

B. DSS-#; Switch and Plug Assemblies: Rated for making and breaking loads, enclosed switch with externally operable interlock to prevent disconnecting receptacle with switch in ON position or inserting receptacle in ON position. Padlock lockable provision to meet OSHA lockout/tagout regulations.

C. Enclosures: Type as indicated on the Disconnect Schedule.

D. Ground lug connection provided in enclosure.

E. Accessories: Matching male pin and sleeve plug, two auxiliary/pilot contacts.

F. Listed UL 2682 suitable for motor disconnect.

2.5 ELEVATOR SERVICE DISCONNECT SWITCH

A. Acceptable Manufacturers:

1. Eaton Bussmann PS Series
2. Mersen ES Series
3. Littlefuse LPS Series

B. Elevator Service Disconnect Switch, three phase fused switch with lockable handle, ratings per drawing schedule, 120 volt shut trip, two field convertible mechanically interlocked form C auxiliary contacts, shunt trip voltage monitor relay, integral control transformer, Pilot Light "on", neutral bar/lug, NEMA 1 enclosure, minimum 100K SCCR, UL Listed.

C. Provide with fire alarm interface relays for:

1. Elevator Recall
2. Elevator Alternative Floor Recall
3. Elevator Shut Down Sequence
4. Fire Fighter's Cab Visual Alarm
5.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install disconnect switches where indicated on the drawings.

B. Install fuses in fusible disconnect switches.

C. Provide adhesive label on inside door of each switch indicating UL fuse class and size for replacement.

3.2 ELEVATOR SERVICE DISCONNECT SWITCH

A. Coordinate installation with elevator requirements and contractor.

B. Coordinate installation with fire alarm contractor.

3.3 ADJUSTING

A. Set field-adjustable circuit breaker trip ranges.

END OF SECTION 26 28 16

SECTION 26 28 21 - CONTACTORS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. General-purpose contactors

B. Lighting contactors

C. Enclosures

1.2 RELATED SECTIONS AND WORK

A. Refer to Lighting Contactor Schedule.

1.3 REFERENCES

A. ANSI/NEMA ICS 6 - Enclosures for Industrial Controls and Systems

B. NEMA ICS 2 - Industrial Control Devices, Controllers, and Assemblies

C. UL 508 - Industrial Control Equipment

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Schneider Electric 8903 Series

B. Eaton Corporation C30CN / CN35 Series

C. ABB

D. Siemens LC / CLM / CM Series

2.2 C-<#>; GENERAL-PURPOSE CONTACTORS

A. Contactors: NEMA ICS 2 and UL 508; mechanically held,-wire control.

B. Coil Operating Voltage: 120 volts, 60 Hertz.

C. Size: NEMA ICS 2; size as indicated on the drawings.

D. Contacts: 30 amp, 600 volts, 60 Hertz.

E. Poles: 3 Field convertible NO and NC configurations.

F. Enclosure: ANSI/NEMA ICS 6; Type 1.

G. Provide solderless pressure wire terminals.

H. Provide Hand-Off-Auto selector switch.

2.3 LC-<#>; LIGHTING CONTACTORS

A. Contactors: NEMA ICS 2 and UL 508; mechanically held,-wire control.

B. Coil Operating Voltage: 277 volts, 60 Hertz.

C. Contacts: 30 amp, 600 volts, 60 Hertz.

D. Poles: 12 Field convertible NO and NC configurations.

E. Enclosure: ANSI/NEMA ICS 6; Type 1.

F. Provide solderless pressure wire terminals.

G. Provide Hand-Off-Auto selector switch.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

C. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.

D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction boxes: and equipment enclosures.

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.

END OF SECTION 26 28 21

SECTION 26 29 23 - VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Variable frequency drives (VFD-#)

1.2 RELATED SECTIONS AND WORK

A. Refer to the Variable Frequency Drive Schedule for rating and configuration.

B. Division(s) 21, 22, 23 - Fire Protection, Plumbing, and Mechanical when referenced.

1.3 REFERENCES

A. ANSI/UL Standard 508

B. ANSI/NEMA ICS 6 - Enclosures for Industrial Controls and Systems

C. IEEE Standard 519-2014 - Guide for Harmonic Control and Reactive Compensation of Static Power Converters

D. FCC Rules and Regulations, Part 15, Subpart J - Radio Frequency Interference

1.4 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 26 05 00.

B. Shop Drawings: Include front and side views of enclosures with overall dimensions and weights shown; conduit entrance locations and requirements; and nameplate legends.

C. Product Data: Provide catalog sheets showing PWM configuration (6, 12, 18 pulse, Active Front End AFE), voltage, controller size, ratings and size of switching and overcurrent protective devices, short circuit ratings, dimensions, and enclosure details.

D. Product Data for Accessories and Options: Provide catalog sheets showing voltage, dimensions, ratings, for accessories and options. Include information for passive harmonic filters, active harmonic filters, line reactors, shielded VFD cabling, output filters, etc. as an inclusive submittal package provided by the VFD supplier. The VFD supplier shall act as a single contact of responsibility.

E. Seismic Requirements: Provide data as defined in Section 26 05 48 Seismic Requirements for Equipment and Supports.

F. Manufacturer's Installation 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.

G. Contractor's Letter of Acknowledgement: The contractor shall include a letter acknowledging the following with date and signature. The letter shall include a location for the installing contractor to sign the document:

1. The manufacturer/vendor received a complete copy of the design document specifications, plans, and schedules as related to the variable frequency drive requirements for the project.
2. The contractor and manufacturer have reviewed the distance relationship between the VFD location and the motor(s) served in conjunction with the installing contractors cable routing plan. The submittal includes compliance with the minimum requirements for each specific application including the addition of harmonic filters and shielded VFD cabling. The contractor is responsible for compiling and documenting information including cable lengths for mutual review with the manufacturer.
3. Leading Power Factor Management: The manufacturer has reviewed the design and identified VFD applications scheduled to operate on a generator power source.

H. VFD Harmonic Analysis:

1. Provide harmonic analysis of each individual variable frequency drive based on the latest IEEE 519 for voltage (THD) and current (TDD) distortion limits at the input terminals of the VFD.
2. Provide a summary of the individual harmonic analysis for each VFD in tabular form to document compliance with the minimum harmonic distortion criteria. Example:

a. VFD - TAG
b. Current distortion (TDD): percent at terminals of VFD
c. Input Line reactor, DC link choke, or LCL filter rating: percent
d. Leading Power Factor Control management applied: Yes or No
e. Filtering: List application specific options and accessories included for compliance with the contract documents and manufacturer recommendations including filters and shielded VFD cabling.

I. IEEE 519 Harmonic Analysis Report: Provide harmonic distortion analysis of the total electrical distribution system. The report shall verify the proposed variable frequency drives proposed do not exceed the latest version of IEEE 519 for voltage (THD) and current (TDD) distortion limits at the PCC. The Point of Common Coupling (PCC) shall be defined as the secondary side of the consumer-utility interface or secondary side of the main service transformer of the facility.

1.5 EXTRA MATERIAL

A. Furnish under provisions of Section 26 05 00.

B. Provide two of each air filter.

C. Provide three of each fuse size and type.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site under provisions of Section 26 05 00.

B. Accept controllers on site in original packing. Inspect for damage.

C. 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.

D. Handle in accordance with manufacturer's written instructions. Lift only with lugs provided for the purpose. Handle carefully to avoid damage.

1.7 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Section 26 05 00.

B. Maintenance Data: Include spare parts data listing, source and current prices of replacement parts and supplies, and recommended maintenance procedures and intervals.

C. Operation Data: Include instructions for starting and operating controllers, and describe operating limits that may result in hazardous or unsafe conditions.

D. Shop Drawings: For each VFD.

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. Include the following:

a. Each installed unit's type and details.
b. Nameplate legends.
c. Short-circuit current rating of integrated unit.
d. UL listing for series rating of overcurrent protective devices in combination controllers.
e. Features, characteristics, ratings, and factory settings of each motor-control center unit.

2. Wiring Diagrams: Power, signal, and control wiring for VFDs. Provide schematic wiring diagram for each type of VFD.

E. Manufacturer Seismic Qualification Certification: Submit certification that VFDs, accessories, and components will withstand seismic forces defined in Division 26 Section 26 05 48 "Seismic Requirements for Equipment and Supports". Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

a. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."
b. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

PART 2 - PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. Variable Torque Applications:

1. Yaskawa Z1000 Series

B. Constant Torque Applications:

1. Yaskawa A1000 Series

C. The Variable Frequency Drive Schedule and drawings use equipment tags to define the scope of the project. The equipment tag (example: VFD-5) may be representative of multiple similar applications. Additional options and accessories may be required by the specifications and manufacturer recommendations due to the specific application but not represented in the Variable Frequency Drive Schedule. Refer to the Options, Accessories, and minimum performance requirements of this specification for a complete list of requirements (example: output filters and shielded VFD cables).

D. Motor Nameplate (Drive Output) Voltage: Refer to Variable Frequency Drive Schedule and Mechanical Schedules when applicable.

2.2 MINIMUM PERFORMANCE, REQUIRED OPTIONS, AND ACCESSORIES

A. The following minimum performance requirements, options, and accessories supplement the requirements of the Variable Frequency Drive Schedule. In the event of a conflict between the schedule and specification the most stringent requirement will be enforced.

1. Manual Speed Adjustment
2. Electronic Thermal Overloads
3. Control Transformer, Fused, 120 volt. Acceptable Alternative, 120 volt / 24 volt power supply available directly from VFD, 100mA minimum.
4. Hand-off-Auto Door Switch
5. Skip Frequency Capability

B. Line Input Reactor: Provide all VFDs with a minimum input line reactor of (3%). The input line reactor may be integral or individually mounted.

1. Exception: The manufacturer may substitute an LCL type harmonic filter with an input harmonic filter; an approximate equivalent (3%) impedance from the harmonic filter is anticipated.
2. Exception: A dual (positive and negative) 3% DC line choke is acceptable in lieu of an input line reactor when coupled with an input harmonic filter. Exception: Not required for Active Front End AFE drives with an IGBT front end instead of a diode-bridge configuration.

C. Forced Ventilation Accessories and Operation: Provide per manufacturer requirements as required for the standard performance of the drive, the application, and environmental conditions.

1. Provide inlet air outlet filter when a fan is provided. Provide an outlet filter if appropriate for the physical construction of the VFD.
2. Field replaceable blower fan sized to maintain VFD at rated operating temperatures for ambient conditions of enclosure location. The VFD manufacturer™™s air change requirements shall be satisfied or exceeded for enclosed applications.

D. Harmonic Distortion Performance Criteria (PCC defined at VFD): The variable frequency drive shall have the following minimum harmonic distortion performance criteria; reference to the latest edition of IEEE 519. The Point of Common Coupling PCC shall be considered the input line terminals of the combination VFD, applicable filters, and accessories for the following requirements.

1. The minimum configuration represents the minimum acceptable solution to achieve THDv and TDDi performance requirements. Alternative approved solutions have been listed and shall be substituted within the scope of the original bid pricing when the minimum configuration does not satisfy the harmonic performance requirements listed.
2. Equivalent HP rating: When a single VFD is configured to serve multiple smaller motors (example: skid packaged equipment, fan wall systems) the equivalent sum of the motor HPs (VFD HP rating) shall be considered the HP rating for the following criteria.
3. VFD rating 15 HP or less:

   a. Minimum Configuration: 6 Pulse with 3% input reactor. A 3% DC line choke is acceptable in lieu of an input line reactor when coupled with an input harmonic filter.

      1) Voltage Total Harmonic Distortion (THDv) limit: 5 percent
      2) Current Total Demand Distortion (TDDi) limit: 5 percent

b. Approved Solutions for Minimum THDv and TDDi Performance: The following approved solutions or a combination of the following is acceptable:

1) Driver Configuration: 6 pulse configuration, 12 pulse configuration, 18 pulse configurations, PWM drives with an Active Front End AFE or "Ultra low harmonic drives" • • that do not limit the maximum motor output power at full load.
2) Passive harmonic filter with a minimum equivalent (3%) impedance when the input line reactor or DC choke is not provided.
3) Active harmonic filter with minimum three percent (3%) input line reactor on the input line terminals of the VFD; or larger per manufacturer requirements.

4. VFD rating exceeding 15HP to 99HP:

a. Minimum configuration: 6 Pulse with 3% input reactor. A 3% DC line choke is acceptable in lieu of an input line reactor when coupled with an input harmonic filter.
b. Minimum Performance Criteria:

1) Voltage Total Harmonic Distortion (THDv) limit: 5 percent
2) Current Total Demand Distortion (TDDi) limit: 5 percent

c. Approved solutions for minimum THDv and TDDi performance: The following approved solutions or a combination of the following is acceptable:

1) Driver Configuration: 6 pulse configuration, 12 pulse configuration, 18 pulse configurations, PWM drives with an Active Front End AFE or "Ultra low harmonic drives" that do not limit the maximum motor output power at full load.
2) Passive harmonic filter with a minimum equivalent (3%) impedance when the input line reactor or DC choke is not provided.
3) Active harmonic filter with minimum three percent (3%) input line reactor on the input line terminals of the VFD; or larger per manufacturer requirements.

5. VFD rating 100HP or larger:

a. Minimum configuration: 6 Pulse with 3% input reactor. A 3% DC line choke is acceptable in lieu of an input line reactor when coupled with an input harmonic filter.
b. Minimum Performance Criteria:

1) Voltage Total Harmonic Distortion (THDv) limit: 5 percent
2) Current Total Demand Distortion (TDDi) limit: 5 percent
3) IEEE 519 compliance at the drive/filter input terminals with a voltage imbalance or 3% or larger, operation at unity power factor, and dynamic braking to prevent regeneration to the supply.

c. Approved solutions for minimum THDv and TDDi performance: The following approved solutions or a combination of the following is acceptable:

1) Driver Configuration: 6 pulse configuration, 12 pulse configuration, 18 pulse configurations, PWM drives with an Active Front End AFE or "Ultra low harmonic drives" • • that do not limit the maximum motor output power at full load.
2) Passive harmonic filter with a minimum equivalent (3%) impedance when the input line reactor or DC choke is not provided.
3) Active harmonic filter with minimum three percent (3%) input line reactor on the input line terminals of the VFD; or larger per manufacturer requirements.

E. Harmonic Distortion Performance Criteria (PCC defined at utility): The variable frequency drive shall have the following minimum harmonic distortion performance criteria, reference to the latest edition of IEEE 519.

1. The minimum configuration represents the minimum acceptable solution to achieve THDv and TDDi performance requirements. Alternative approved solutions have been listed and shall be substituted within the scope of the original bid pricing when the minimum configuration does not satisfy the harmonic performance requirements listed.
2. Equivalent HP rating: When a single VFD is configured to serve multiple smaller motors (example: skid packaged equipment, fan wall systems) the equivalent sum of the motor HPs (VFD HP rating) shall be considered the HP rating for the following criteria.
3. Harmonic Distortion Compliance Method:

a. Minimum Configuration: 6 Pulse with 3% input reactor. A 3% DC line choke is acceptable in lieu of an input line reactor when coupled with an input harmonic filter.
b. Minimum Performance Criteria: IEEE 519 latest edition compliance at the utility service Point of Common Coupling PCC. The THD shall not exceed IEEE 519 nor the following criteria, whichever is more stringent.

1) Voltage Total Harmonic Distortion (THDv) limit: 5 percent
2) Current Total Demand Distortion (TDDi) limit: 5 percent
3) Perform harmonic system analysis prior to bid. Include additional input line reactors, filters, etc. for IEEE 519 compliance with bid. Refer to Approved Solutions for minimum THDv and TDDi performance below.

c. Approved solutions for minimum THDv and TDDi performance: The following approved solutions or a combination of the following is acceptable in lieu of the minimum configuration for compliance with IEEE 519:

1) Driver Configuration: 6 pulse configuration, 12 pulse configuration, 18 pulse configurations, PWM drives with an Active Front End AFE or "Ultra low harmonic drives" • • that do not limit the maximum motor output power at full load.
2) Passive harmonic filter with a minimum equivalent (3%) impedance when the input line reactor or DC choke is not provided.
3) Active harmonic filter with minimum three percent (3%) input line reactor on the input line terminals of the VFD; or larger per manufacturer requirements.

F. Existing Conditions - Performance Verification: The scope includes the addition, of an existing facility.

1. Measure Pre-existing Conditions: The contractor shall use a power quality meter to measure the pre-existing THDv and TDDi conditions of the facility at the electrical service entrance. The measurement shall be performed prior to any new equipment being installed. Include results of measurements with submittals: Include the following results:
2. Measure Installed Conditions: The contractor shall use a power quality meter to measure the post-installation THDv and TDDi conditions of the facility at the electrical service entrance. The measurement study may be performed during building commissioning, . Submit with O&M documents.
3. Include the following data for each test:

a. THDv (voltage)
b. TDDi (current)
c. Power Factor
d. Maximum Demand Current IL (Amps)

4. The minimum power metering duration per test shall be: 2 days.

G. VFD Output Load Terminals - Minimum Design Requirements:

1. Provide external output line reactors, DV/DT, sine filters, and shielded VFD cable when the manufacturer™™s recommended maximum distance between the VFD and the motor(s) is exceeded.
2. Provide the following minimum design criteria in addition to manufacturer recommendations:

   a. Output line reactor (3 percent): When recommended by manufacturer.
   b. DV/DT output line reactor: VFD to motor distance exceeds 75 feet (480 volt) or 150 feet (240/208 volt).
   c. Sine Wave Output Line Reactor: VFD to motor distance exceeds 150 feet (480 Volt) or 280 feet (240/208 Volt).
   d. Shielded VFD Motor Cable: Horsepower ratings exceeds 100 HP for any cable length.

H. Leading Power Factor Management: The project includes a packaged engine emergency generator. VFD applications including a capacitor solution (example: Harmonic Filters) shall include provisions to disconnect or step control the capacitor components when the associated motor load is not operating to prevent a leading power factor while operating on the generator power source.

2.3 VFD DESCRIPTION, RATINGS, DESIGN

A. Pulse Width Modulated (PWM) Variable Frequency Drives:

1. Converter shall be of a diode bridge design with a sine-weighted PWM inverter section. Converts 60 Hertz input power at voltage specified to a variable AC frequency and voltage for controlling the speed of AC motors. The controller shall be suitable for use with standard inverter duty motors without requiring any modifications to the motor or the drive.
2. Drives shall be capable of use with commercially available Internal Permanent Magnet (IPM) motors up to 12 poles.
3. Main semi-conductors in the inverter section of controller shall be IGBT transistors capable of a carrier switching frequency of up to 8 kHz.

   a. 50HP applications and less: If derating of the inverter is necessary to run at 8kHz, then the unit™™s derated currents must equal or exceed the motor full load currents listed in NEC Table 430-150.

B. Active Front End (AFE) Variable Frequency Drives:

1. Active Frond End (AFE) variable frequency drive with an Insulated Gate Bipolar Transistor (IGBT) based front end and LCL filter to mitigate switching noise. The AFE shall allow for regenerative power flow unless associated with a distribution system using a packaged engine generator.

C. Short Circuit Current Rating SCCR Default: 100 KA. Provide integral circuit breaker or fuse switch with disconnect switch when required to achieve rating.

D. Drive and controller shall be capable of continuous full load operations throughout the following specified environmental operating conditions. Drive shall be capable of operation in the 'forward' and 'reverse' direction.

1. Operating Ambient Temperature: 0°C to 40°C.
2. Minimum Relative Humidity Range: 5% to 90% (non-condensing).
3. Minimum Elevation without Derating: 3300 feet.
4. The VFD shall incorporate a protective coating on the main control board to conform to IEC60721-3-3 class 3C2 levels.

E. Input Voltage Performance: The drive shall provide full rated output from a line voltage range of -15 / +10% nominal voltage.

F. Controller shall have the functional components listed below:

1. Door interlocked input circuit breaker/fused switch.
2. Input rectifier section to supply fixed DC bus voltage.
3. Smoothing reactor or choke for DC bus.
4. DC bus capacitors.
5. Control transformer or switch mode powered from all three phases.
6. Separate terminal blocks for power and control wiring.
7. Terminal block for operator controls.
8. Sine weighted PWM generating inverter section.

G. Enclosure Fabrication:

1. Enclosure: NEMA 250, Type 1, unless otherwise specified.
2. Finish: Manufacturer's standard enamel.
3. Devices shall be factory installed in controller enclosure and functionally tested unless otherwise indicated.

H. Displays: Provide integral digital display to indicate all protection faults and drive status (including overcurrent, overvoltage, undervoltage, ground fault, overtemperature, phase loss, input power ON, output voltage, output frequency, and output current). Include meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate the following controller parameters:

1. Output frequency (Hz).
2. Motor speed (rpm).
3. Motor status (running, stop, fault).
4. Motor current (amperes).
5. Motor torque (percent).
6. Fault or alarming status (code).
7. PID feedback signal (percent).
8. DC-link voltage (VDC).
9. Set-point frequency (Hz).
10. Motor output voltage (V).

I. Status Indication Door-mounted display shall indicate the following conditions:

1. Power on.
2. Run.
3. Overvoltage.
4. Line fault.
5. Overcurrent.
6. External fault.

J. Historical Logging Information and Displays:

1. Real-time clock with current time and date.
2. Running log of total power versus time.
3. Total run time.
4. Fault log, maintaining last four faults with time and date stamp for each.

K. Panel-Mounted Operator Station or KeyPad, Start-stop, auto-manual selector switches with manual speed control potentiometer, and elapsed time meter: NEMA ICS 2, heavy-duty type.

L. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.

M. Control Relays: Auxiliary and adjustable time-delay relays.

N. Protection:

1. Input transient protection by means of surge suppressors or equivalent protection.
2. Snubber networks to protect against malfunctions due to system transients.
3. Under- and overvoltage trips; inverter overtemperature, overload, and overcurrent trips.
4. Power-Interruption Protection: After a power interruption, it prevents the motor from re-energizing until the motor has stopped.
5. Motor thermal overload relay(s) adjustable and capable of NEMA Class 20 motor protection and sized per motor nameplate data. When multiple motors are connected to the VFD output, each motor shall have a manual starter with properly sized overload protection.
6. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination. Skip frequency feature is acceptable.
7. Instantaneous line-to-line and line-to-ground overcurrent trips on input and output.
8. Loss-of-phase protection.
9. Reverse-phase protection.
10. Short-circuit protection (fuses or circuit breaker).
11. Motor overtemperature fault.
12. Loss of load protection.

O. For a fault condition other than an internal fault, an auto restart function shall provide up to 10 programmable restart attempts. The programmable time delay before each restart shall range from 0 to 10 seconds.

P. The deceleration ramp of the controller shall be programmable for normal and fault conditions. Stop modes shall include: DC injection braking, controlled deceleration to stop and coast to stop.

Q. Upon loss of the analog speed reference signal the following shall be selectable:

1. The VFD follows the programmed deceleration ramp to a controlled stop.
2. The VFD holds the speed based upon the last good value and trigger a warning alarm.

R. The VFD operates at a pre-determined frequency (user programmable).

S. STOP key on the keypad shall be functional at all time, drive mode insensitive.

T. The VFD shall be insensitive to input power phase sequence. Input phase loss detection shall be available.

U. The output frequency shall be parameter setting enabled to fold back when the motor is overloaded (stall prevention).

V. For pump applications, the VFD shall incorporate a forward/reverse pump start sub-routine to assist with clogging.

W. An optional real time clock feature shall be available, which must facilitate the time stamping of any drive trip messages.

X. The VFD shall monitor the main circuit capacitors, control circuit capacitor, in-rush suppression circuit, and cooling fan and shall provide a pre-alarm so that maintenance can be scheduled.

Y. The VFD shall include an output timer function so that peripheral equipment maintenance can be scheduled.

Z. The VFD shall include parameter selectable input and output phase loss protection.

AA. The VFD basic insulation level shall be tested based upon ANSI/IEEE C62.41-1999.

BB. The VFD shall be rated as a safety VFD (STO) EN ISO 13849-1 PLd/Cat.3, EN61508, and EN61800-5-2 SIL 1 without additional options.

CC. Displacement Power Factor: Between 1.0 and 0.95, lagging, over entire range of operating speed and load.

DD. Minimum Efficiency at Full Load: 96 percent.

EE. Overload Capability: 1.1 times the base load current for 60 seconds every 10 minutes; 1.3 times the base load current for 2 seconds every minute.

FF. Starting Torque: 100 percent of rated torque or as indicated.

GG. Speed Regulation: Plus or minus 1 percent with no motor derating.

HH. All drives shall have built-in diagnostic capability with status and fault indicators mounted on enclosure door. Complete operating instructions for diagnostics shall be mounted inside of the enclosure door.

II. The drive shall provide self-protection when the load is lost or disconnected without damage to the drive.

JJ. Acceleration Rate Adjustment: 0.5 - 30 seconds.

KK. Deceleration Rate Adjustment: 1 - 30 seconds.

LL. Minimum Adjustment Range for the Output Frequency shall be: 0 to 90 Hertz.

MM. Minimum Volts/Hertz Range: 3.7 to 8.6 volts/Hertz.

NN. Provide MANUAL-OFF-AUTOMATIC selector switch and manual analog speed control mounted on the front of the enclosure.

OO. Safety Interlocks: Provide terminals for remote contact to inhibit starting under both manual and automatic mode.

PP. Control Interlocks: Provide terminals for remote contact to allow starting in automatic mode.

QQ. Provide adjustable skip frequencies on the drive output (minimum of three ranges).

RR. Automatic Reset/Restart: Attempts up to 10 restarts after controller fault, on return of power after an interruption, or on undervoltage fault, and before shutting down for manual reset or fault correction. Bidirectional autospeed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load (coasting motor re-start).

SS. Excitation Control will regulate motor output voltage based on torque requirement. Must be able to provide full motor torque when necessary across the operating speed range.

TT. Motor Temperature Compensation at Slow Speeds: Adjustable current fallback based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

UU. Control Transformer: Provide control power transformer for control, 120 volt secondary, fused.

VV. Control Signal Interface:

1. Electric Input Signal Interface: A minimum of 2 analog inputs (0 to 10 V or 0/4-20 mA) and 6 programmable digital inputs.
2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BMS or other control systems:

   a. 0 to 10-V dc.
   b. 0-20 or 4-20 mA.
   c. Potentiometer using up/down digital inputs.

d. Fixed frequencies using digital inputs.
e. RS485.
f. Ethernet.
g. Keypad display for local hand operation.

3. Output Signal Interface:

a. A minimum of 1 analog output signal (0/4-20 mA), which can be programmed to any of the following:

1) Output frequency (Hz).
2) Output current (load).
3) DC-link voltage (VDC).
4) Motor torque (percent).
5) Motor speed (rpm).
6) Set-point frequency (Hz).

4. Remote Indication Interface: A minimum of 2 dry circuit relay outputs (120-V ac, 1A) for remote indication of the following:

a. Motor running.
b. Set-point speed reached.
c. Fault and warning indication (overtemperature or overcurrent).
d. PID high- or low-speed limits reached.

5. The control power for the VFD digital inputs and outputs shall be 24Vdc, selectable to sink or source. Optional 120Vac control power for the digital inputs and outputs shall be available.
6. The drive control board shall be capable of operating from an independent 24V dc power supply.
7. All logic connections shall be furnished on a removable terminal strip.
8. External devices shall be able to be connected to the terminal strip for starting/stopping the VFD, speed control and indicating operation status.
9. Speed command input shall be by means of:

a. Keypad.
b. Analog input.
c. Serial communications.
d. Ethernet communications.

WW. Communications: Provide a communications card to interface VFD with Facility Management Control System (FMCS). Coordinate interface requirements with the FMCS provided under Section 23 09 00. Interface shall allow all parameter settings of VFD to be programmed via FMCS control and displayed on FMCS operator workstation. Provide capability for VFD to retain these settings within the nonvolatile memory.

XX. Control:

1. With the "Manual-Off-Auto" switch in the "Manual" position and, if applicable, the "Drive-Bypass" in the "Drive" position, the drive shall be controlled by the manual speed potentiometer on the drive door or keypad.
2. With the "Manual-Off-Auto" switch in the "Auto" position and, if applicable, the "Drive-Bypass" in the "Drive" position, the drive shall be controlled by the input signal from an external source.
3. If applicable, with the "Drive-Bypass" in the "Bypass" position, regardless the position of the "Manual-Off-Auto" switch, the motor shall be connected across the lines and shall be run at full speed.
4. With the "Manual-Off-Auto" switch in the "Off" position, if applicable, the drive run circuit shall be open and the VFD shall not operate.
5. If applicable, signal from the fire alarm control panel shall shut down VFD and bypass to direct-on-line operation. In this mode the thermal overload relay for the motor must be disabled.

YY. All disconnect switches between VFD and motor(s) shall include an auxiliary contact interlock wired to the VFD fault trip input to shut down the drive upon opening of the disconnect main contacts.

ZZ. Convertible Auxiliary Contacts (additional): Provide two additional convertible normally open / normally closed contacts.

AAA. Electronic Thermal Overloads: Provide adjustable electronic type thermal overloads. Size protection per motor nameplate data.

BBB. Multiple Motor Thermal Overloads: Provide manual starter disconnect switch with electronic thermal overloads for each individual motor when the VFD is scheduled to server multiple motors. Size protection per motor nameplate data.

2.4 OPTIONS AND ACCESSORIES - DESCRIPTIONS

A. Passive Harmonic Filter: LCL (input line reactor, capacitor, tuned inductor) type sized by manufacturer for application. Provide leading power factor management for when the motor/VFD are not operating.

1. When required:

a. As required to satisfy, the Harmonic Distortion Performance Criteria descripted in Part 2 of this specification.
b. Per VFD schedule.

B. Active Harmonic Filter: LCL (input line reactor, capacitor, tuned inductor) type sized by manufacturer for application. Provide leading power factor management for when the motor/VFD are not operating. Provide all VFDs coupled with an Active Harmonic Filter with a minimum three percent (3%) input line reactor; or larger per manufacturer requirements.

1. When required:

a. As required to satisfy, Harmonic Distortion Performance Criteria descripted in Part 2 of this specification.
b. Per VFD schedule.

C. Active Bridge Rectifier Stage: Capable of limiting current harmonic distortion at the drive input terminals.

1. When required:

a. As required to satisfy, Harmonic Distortion Performance Criteria descripted in Part 2 of this specification.
b. Per VFD schedule.

D. Dynamic Braking: The VFD shall incorporate terminals for adding an external braking unit to allow for dissipation of excessive electrical energy from the motor. Provide dynamic braking with load resistor or DC injection braking to provide a means of rapid deceleration of the AC motor within one (1) minute. Adjust the controls to stop the motor within 30 seconds.

1. When required:

a. 100HP or larger applications.
b. VFD served by package engine generator.
c. Per VFD schedule or other portions of this specification.
d. All VFDs supplied for fan applications when VFD is not capable of capturing a free spinning load without damage to the VFD or motor.

2. All high inertia loads that cannot be stopped in 30 seconds with the VFD dynamic braking or DC injection braking shall be provided with a chopper module and dynamic braking resistor to stop the motor within 30 seconds. The following options shall be available:

   a. Adjustable operation frequency, time, and voltage.
   b. External line regeneration.
   c. Shared DC bus capability systems for multiple drive regeneration.

E. Three- Contactor Automatic Bypass:

1. When required: Per VFD schedule.
2. Provide contactors, motor running overload protection, under-voltage and loss of phase protection, and short circuit protection for full voltage, non-reversing operation of the motor. Include isolation switch or third contactor to allow maintenance of inverter during bypass operation.
3. All bypass circuitry shall be located within the same enclosure as the variable frequency drive.
4. All fire alarm and/or smoke control interconnections (e.g., air handling unit shutdown) shall apply regardless of whether control is through VFD or bypass.
5. Provide a Drive-Bypass Selector Switch.
6. When operating in bypass mode, the main power supply to the VFD shall be disconnected and isolated for service.
7. Provide nameplate with instructions for switching from drive to bypass and from bypass to drive. Provide instructions for isolating VFD for maintenance.

F. Shielded VFD Motor Cable:

1. When required:

   a. Per VFD schedule.
   b. Required by other portions of this specification.
   c. Recommended by the manufacturer.

2. Multi-conductor single overall jacket cable, AC motor application controlled by PWM pulse-width modulation VFD applications, minimum 2000 volt rated, copper phase conductor(s) to match motor application and ratings, three copper conductor ground in direct contact with shield, copper tape or braided shield, provide with wire termination kits at VFD and motor, install per manufacturer recommendations.
3. Conduit Raceway: Contractor to size raceway per code and cable cross sectional area provided by manufacturer.
4. Installation: Contractor shall install without cable splices between VFD and motor unless approved by engineer prior to installation.

G. Forced Cooling / Heating Cabinet Enclosure:

1. When required:

   a. Per VFD schedule.
   b. When VFD is located exterior to the building or specified with a NEMA 3R, 4, 4X, or 12 enclosure.

2. Provide custom VFD enclosure with DX based cooling system, strip heaters, and thermostat temp controller.

PART 3 - EXECUTION

3.1 FACTORY TESTING

A. Refer to startup and commissioning requirements.

B. The VFD and all associated controller components shall be covered by a supplier parts warranty of 2 years from the time of installation. There shall be an option to extend the warranty to 5 years if initial installation is carried out by a supplier-approved contractor.

3.2 INSTALLATION

A. Install variable frequency drive equipment in accordance with the manufacturer's instructions.

B. Install harmonic filter components in accordance with manufacturer’s instructions. Locate filters above or below VFD to minimize use of available horizontal wall space pending field conditions.

C. Adjust VFD settings per recommendations of the harmonic filter manufacturer’s instructions; example: switching frequency.

D. VFD Output Feeder and Raceway: The contractor shall provide VFD shielded cable for the VFD output feeder when the distance to the motor exceeds manufacturer recommendations or the requirements of this specifications. Contractor to size raceway per code and cable cross sectional area provided by manufacturer.

E. Floor mount VFD on prefabricated or field fabricated supports with controls no higher than 6'-6" and no lower than 3'-0" AFF. Mount supports on 1/2" thick vibration isolation pads set on concrete housekeeping pads.

F. Provide engraved phenolic nameplates under the provisions of Section 26 05 53.

G. Connections: All conduit connections to the VFD shall be by flexible conduit.

H. Input, output, and control wiring shall each be run in separate conduits.

I. All interlocking required by the drive manufacturer shall be the responsibility of the Electrical Contractor.

J. Forced Cooling / Heating Cabinet Enclosure: Coordinate installation with field conditions and manufacturer instructions. Provide additional branch circuit(s) for cooling and heating system per manufacturer requirements.

3.3 STARTUP AND COMMISSIONING

A. The Electrical Contractor shall have a factory service engineer present for the start-up, field calibration, and check-out of each VFD installed. Factory service engineer shall be required to return to the site for recalibration or set-up should unit not function as specified during system commissioning. All costs shall be a part of This Contract. Provide tag with date and signature of factory service Engineer on inside cover of each drive.

B. Verify all settings, parameters, and adjustments with other contractors prior to startup. Make all adjustments and setting to coordinate with controls and equipment.

C. Accelerate the motor to full speed and verify operation. Decelerate the motor to a stop and verify operation. Slowly operate the motor over the speed range and check for resonance.

D. Make all adjustments and settings to coordinate with controls and equipment prior to Substantial Completion. Verify that drive is set for auto restart after power loss and undervoltage fault.

E. Document settings in the Operations and Maintenance manual.

END OF SECTION 26 29 23

SECTION 26 32 13 - PACKAGED ENGINE GENERATOR SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Packaged engine generator system

B. Heat exchanger

C. Fuel fittings and day tank

D. Battery and charger

E. Weatherproof enclosure

1.2 REFERENCES

A. ANSI/NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum)

B. ANSI/NEMA AB 1 - Molded Case Circuit Breakers

C. ANSI/NEMA MG 1 - Motors and Generators

D. NFPA 37 - Installation and Use of Stationary Combustion Engines and Gas Turbines

E. NFPA 70 - National Electrical Code (NEC)

F. NFPA 110 - Standard for Emergency and Standby Power Systems

G. Environmental Protection Agency EPA Emission Standards for Compressed Ignition Engines

H. Noise Emission: Comply with applicable state and local government requirements for maximum noise level at property boundaries due to sound emitted by the generator set, its components and the operation thereof.

1.3 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 26 05 00.

B. Submit shop drawings showing plan and elevation views with overall and interconnection point dimensions, fuel consumption rate curves at various loads, ventilation and combustion air requirements, and electrical diagrams including schematic and interconnection diagrams.

C. Submit product data showing dimensions, weights, ratings, interconnection points, and internal wiring diagrams for engine, generator, control panel, battery, battery rack, battery charger, exhaust silencer, vibration isolators, day tank, remote radiator, and remote annunciator.

D. Submit certificates for compliance with EPA Emissions Standards for Compressed Ignition Engines.

E. Submit manufacturer's installation instructions under provisions of Section 26 05 00.

1.4 EXTRA MATERIALS

A. Submit maintenance materials under provisions of Section 26 05 00.

B. Furnish one set of tools required for preventative maintenance of the engine generator system. Package tools in adequately sized metal toolbox.

C. Provide two additional sets of each fuel, oil, and air filter element required for the engine generator system. Provide additional fuel polishing filters for one year of operation.

D. Provide one fuse for every type and rating used.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of Section 26 05 00.

B. Store and protect products under provisions of Section 26 05 00.

C. Accept packaged engine generator set and accessories on site in crates and verify damage.

D. Protect equipment from dirt and moisture by securely wrapping in heavy plastic.

1.6 SYSTEM DESCRIPTION

A. Engine generator system to provide source of emergency and standby power.

B. System Capacity: 1250KW,1562KVA at an elevation of 1,000 feet above sea level, and ambient temperature between -20°F and 110°F;[continuous][standby] rating using[engine-mounted radiator.][remote radiator.]

C. Emergency Power Supply System (EPSS) shall be NFPA 110 Type 10 Class 2 Level 1.

1.7 COORDINATION DRAWINGS

A. Reference Coordination Drawings article in Section 26 05 00 for required generator electronic CAD drawings to be provided to Coordinating Contractor for inclusion into composite coordination drawings. Show generator, fuel system components, battery system components, and exhaust system in 1/4" scale plan of room.

1.8 PROJECT RECORD DOCUMENTS

A. Submit record documents under provisions of Section 26 05 00.

B. Accurately record location of engine generator and mechanical and electrical connections.

1.9 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Section 26 05 00.

B. Include instructions for normal operation, routine maintenance requirements, service manuals for engine and day tank, oil sampling and analysis for engine wear, and emergency maintenance procedures.

1.10 QUALIFICATIONS

A. Manufacturer: Company specializing in packaged engine generator system with minimum five (5) years documented experience.

B. Supplier: Authorized distributor of engine generator manufacturer with service facilities within 50 miles of the project site.

1.11 WARRANTY

A. Provide a five (5) year warranty under provisions of Section 26 05 00.

1.12 MAINTENANCE SERVICE

A. Furnish service and maintenance of packaged engine generator system for one (1) year from Date of Substantial Completion. Maintenance service shall be performed by skilled employees of manufacturer's designated service organization. Include quarterly exercising, and routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Maintenance agreements shall include parts, supplies, and labor.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Caterpillar.

B. Cummins Power Generation.

C. MTU On Site Energy (Basis of Design).

2.2 PACKAGED ENGINE-GENERATOR SET

A. Packaged engine-generator set shall be a coordinated assembly of compatible components. Stationary generators shall be listed.

B. Safety Standard: Comply with ASME B15.1 and UL 2200.

C. Nameplates: Each major system component shall be equipped with a nameplate to identify manufacturer's name and address, model and serial number, and component rating in integrated set and as required by the contract documents.

D. Fabricate engine-generator set mounting frame and attachment of components to resist generator-set movement during a seismic event when generator-set mounting frame is anchored to building structure.

E. Mounting Frame: Adequate strength and rigidity to maintain alignment of mounted components without depending on concrete foundation. Mounting frame shall be free from sharp edges and corners and shall have lifting attachments arranged for lifting with slings without damaging components. Provide a rigging diagram permanently attached to the mounting frame to indicate the capacity of each lifting attachment and the generator-set center of gravity.

F. Maximum Dimensions: 240"L x 144"W x 144"H.

2.3 ENGINE

A. Type: Water-cooled in-line or V-type, compression ignition diesel electric ignition internal combustion engine.

B. Rating: Sufficient to operate at 100 percent load for two hours at specified elevation and ambient limits.

C. Fuel: Appropriate for use of No. 2 fuel oil.

D. Engine Speed: 1800 RPM.

E. Governor: Isochronous type with speed sensing.

F. Safety Devices: Engine shutdown on high water temperature, low oil pressure, overspeed, and engine overcrank. Limits as selected by manufacturer.

G. Frequency Response:

1. Steady State Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.
2. Transient Response: Less than 5 percent for a 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady state operating band within 5 seconds.

H. Fuel System:Engine mounted diesel fuel pump and relief-bypass valve.

1. Provide base mounted fuel tank sized for operation of the generator for 1-2 days of continuous operation at full load.
2. Provide evaluation of runtime for each size of tank so tank size final decision can be made.

3. Provide a catwalk on top of fuel tank if needed to ensure access to service generator and engine without a ladder.

I. Engine Jacket Heater: Thermal circulation type water heater with integral thermostatic control, sized to maintain engine jacket water at 90°F, and suitable for operation on 480-3Ø volts AC. The minimum wattage of the heater shall be watts or as recommended by the manufacturer.

J. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine-generator set mounting frame and integral engine-driven coolant pump.

1. GRR-; Remote Radiator: Horizontal air discharge. Multiple belt drive from totally enclosed sealed bearing motor. Sized by generator manufacturer.
2. Fan and Core: Nonferrous-metal construction sized to contain expansion of total system. Blower type fan, sized to maintain safe engine temperature in ambient temperature of 110°F. Radiator Airflow Restriction: 0.5 inches of water, maximum.
3. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anti-corrosive additives.
4. Provide expansion tank with gage glass and petcock, and self-contained, thermostatic-control temperature control valve.

K. Engine Starting: DC starting system with positive engagement, number and voltage of starter motors in accordance with manufacturer's instructions. Include remote starting control circuit, with MANUAL-OFF-REMOTE selector switch on engine-generator control panel. Provide the following accessories:

1. Battery: Voltage to match starter with capacity for three cranking cycles without recharge. Provide with battery cables and acid resistant battery tray.
2. Battery-Charging Alternator: Factory mounted on engine with solid state voltage regulation.
3. Remote Start Circuit Monitoring: Provide continuous monitoring of the generator start circuits. A failure shall initiate visual and audible alarms at the generator, remote annunciators, and start the generator.

4. BC- Battery Charger: Current limiting type designed to float at 2.17 volts per cell and equalize at 2.33 volts per cell. Include overload protection, full wave rectifier, DC voltmeter and ammeter, and 120 volts AC fused input. Provide wall-mounted enclosure to meet ANSI/NEMA 250, Type 1 requirements.
5. DC Power Supply/Charger: Utility grade current limiting type with battery temperature compensation designed to float at 2.17 volts per cell and equalize at 2.33 volts per cell. Include overload protection, full wave filtered rectifier, digital DC voltmeter and ammeter, and 120 volts AC fused input. Provide wall-mounted enclosure to meet ANSI/NEMA 250, Type 1 requirements.

L. Exhaust System: Critical type silencer (85 dBA max at 10 feet), side inlet with muffler companion flanges and flexible stainless steel exhaust fitting, suitable for horizontal orientation, sized in accordance with engine manufacturer's instructions. Silencer shall include a threaded opening for connection of ¾" drain line. Opening shall be flush on inside of silencer.

M. The packaged engine generator shall comply with the current Environmental Protection Agency EPA Emissions standards.

N. Engine Accessories: Fuel filter, lube oil filter, intake air filter, lube oil cooler, fuel transfer pump, fuel priming pump, gear-driven water pump. Include fuel pressure gauge, water temperature gauge, and lube oil pressure gauge on engine-generator control panel.

O. Mounting: Provide unit with suitable spring-type vibration isolators.

2.4 GENERATOR

A. Generator: ANSI/NEMA MG 1; three phase, re-connectible brushless synchronous generator with brushless exciter and PMG alternator excitation.

B. Rating: As indicated on the drawings, at 0.8 power factor, 60 Hertz at RPM to match engine rating.

C. Insulation: ANSI/NEMA MG 1, Class F.

D. Temperature Rise: 105°C continuous.

E. Enclosure: ANSI/NEMA MG 1; open drip-proof.

F. Voltage Regulation:

1. The maximum instantaneous voltage dip (IVD) shall be 30 percent for building loads and 15 percent for the fire pump.
2. Include solid-state type voltage regulator, separate from exciter to match engine and generator characteristics, with voltage regulation ±1 percent from no load to full load. Include manual controls to adjust voltage drop ±5 percent voltage level, and voltage gain.

G. Subtransient Reactance (X'd): Maximum 15 percent.

H. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

I. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

2.5 CONTROLS AND INDICATION

A. Operating and safety indications, protective devices, basic system controls, and engine gauges 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.

B. Ground Fault: Provide ground fault sensing at the generator. The sensor shall be located ahead of the generator service disconnect. Provide a ground fault indication on the engine-generator control panel. Provide an instruction nameplate at the control panel.

1. Instruction nameplate: Provide operational instructions for a ground fault indication as approved by the local Authority Having Jurisdiction.

C. GCP-; Engine-Generator Control Panel: ANSI/NEMA 250, Type 1 generator mounted control panel enclosure with engine and generator controls and indicators. Include provision for padlock and the following equipment and features:

1. Alarm indication as required by NFPA 110 for a Level 2 system.Dry contacts for alarms to tie into building management system. exercising of generator shall be scheduled by building management system.
2. AC frequency meter.
3. AC output voltmeter with phase selector switch.
4. AC output ammeter with phase selector switch.
5. Output voltage adjustment.
6. DC voltmeter (alternator battery charging).
7. Engine start/stop selector switch.
8. Engine running time meter.
9. Oil pressure gauge.
10. Engine coolant temperature gauge.
11. Shut down devices for overspeed, coolant high-temperature, coolant low-level, and oil low-pressure.
12. Fuel derangement alarm.
13. Generator overload.
14. Auxiliary Relay: 3PDT, operates when engine runs, with contact terminals prewired to terminal strip.
15. Remote Alarm Contacts: Pre-wire SPST contacts to terminal strip for remote alarm functions required by ANSI/NFPA 99.
16. Ground fault indication.
17. Generator control and start signal failure.

D. GANN-; Remote Engine Annunciator Panel: ANSI/NFPA 99 and NFPA 110 for a Level 1 system. Include the listed pre-alarm and alarm points, audible alarm, alarm silencing means, repetitive alarm circuitry, and lamp test switch in a surface mounted panel with brushed stainless steel finish. Provide all interconnecting wiring in conduit per manufacturer's requirements by the Electrical Contractor. Remote annunciator to be mounted in transfer switch room. The remotely reported alarms shall include the following.

1. Overcrank
2. Low water (engine) temperature
3. High engine temperature pre-alarm
4. High engine temperature
5. Low lube oil pressure pre-alarm
6. Low lube oil pressure
7. Overspeed
8. Low fuel main tank
9. Low coolant level
10. Not in auto
11. Emergency Power Supply (EPS) supplying load
12. High battery voltage
13. Low battery voltage
14. Battery charger failure (includes AC failure)
15. Generator running
16. Normal utility power
17. Emergency stop
18. Emergency Power Off Switch activated (EPO)
19. Alarm for power supply or UPS serving motorized breakers
20. Generator control and start signal failure.

E. Remote Engine Manual Start Control: Two-wire remote start control from fire command center. Provide all interconnecting wiring in conduit per manufacturer's requirements (by the Electrical Contractor).

F. Building Automation System Integration:

1. Provide a terminal block to allow the Facility Monitoring and Control System (FMCS) to report generator alarms. Provide individual terminal points for each of the annunciator alarms and pre-alarms. Provide an additional terminal point to combine all generator alarms under a single terminal point. Provide a permanent label for each terminal point. Each terminal will provide a binary output for the FMCS to read. Provide dry contacts for alarms to tie into building management system. Exercising of generator shall be scheduled and activated by the building management system. Refer to Section 23 09 00 for alarms reported by the FMCS.

2.6 ACCESSORIES

A. Generator Circuit Breaker: Molded or insulated case, service-rated electronic trip type; 100% rated breaker complying with NEMA AB1 and UL 489. The disconnect shall simultaneously open all associated ungrounded conductors and be lockable in the open position.

1. Tripping Characteristic: Designed specifically for generator protection.
2. Trip Rating: Matched to generator rating.
3. Shunt Trip: Connected to trip breaker when generator is shut down by other protective devices.
4. Mounting: Provide freestanding enclosure or mount integrally with control and monitoring panel.
5. The disconnecting means shall also shut down the prime mover, disable all start control circuits, and be configured with a mechanical reset.
6. Arc Energy Reduction: Provide and arc energy reduction system to reduce the clearing time of an arc flash event. The arc energy system shall be provided for overcurrent protection devices rated 1,200 amps or larger.

B. EPO; Remote Manual Stop Station (Emergency Power Off EPO): Provide a remote manual stop station with weatherproof stainless steel or die cast housing, red mushroom button - push to stop operation, breakable cover/lens to access mushroom button, 120-volt rated. The manufacturer shall provide automatic monitoring of the EPO switch. Placing the EPO switch in the "Generator Powered OFF" status shall initiate a visual and audible alarm at each generator annunciator panel.

C. Provide dual redundant engine starters. The redundant engine starters shall be configured to start the engine when the primary engine starter fails.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that surfaces are ready to receive work and field dimensions are as shown on the drawings.

B. Verify that required utilities are available in proper location and ready for use.

C. Beginning of installation means installer accepts existing conditions.

3.2 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install remote manual stop station in location shown on plans. Provide 120 Volt power and wiring in conduit as required. Coordinate installation with the manufacturer approved shop drawings and wiring diagrams. The remote manual stop station shall shunt trip the generator mounted circuit breaker and signal the engine prime mover to stop.

C. The A-B-C phase rotation of the generator source shall match the A-B-C phase rotation of the utility source. The Contractor shall verify the generator and utility phase rotation match to prevent three phase motors and similar loads from operating backwards while being served by the generator.

3.3 FIELD QUALITY CONTROL

A. Field inspection and testing will be performed under provisions of Section 26 05 00 and in compliance with NFPA 110 requirements.

B. Provide portable test bank for full load test, if required. Simulate power failure including operation of transfer switch, automatic starting cycle, and automatic shutdown, and return to normal.

C. Fill fuel tank prior to start of test.

D. The on-site installation test shall be conducted as follows:

1. With the prime mover in a "cold start" condition and the emergency load at standard operating level, a primary power failure shall be initiated by opening all switches or breakers supplying the primary power to the building or facility.
2. The test load shall be that load that is served by the Emergency Power Supply System (EPSS).
3. The time delay on start shall be observed and recorded.
4. The cranking time until the prime mover starts and runs shall be observed and recorded.
5. The time taken to reach operating speed shall be observed and recorded.
6. The voltage and frequency overshoot shall be recorded.
7. The time delay on transfer to emergency power for each switch shall be recorded. Life safety and critical branch transfer switches must transfer within 10 seconds.
8. The time taken to achieve a steady-state condition with all switches transferred to the emergency position shall be observed and recorded.
9. The voltage, frequency, and amperes shall be recorded.
10. The prime mover oil pressure and water temperature shall be recorded, where applicable.
11. The battery charge rate shall be recorded at 5-minute intervals for the first 15 minutes and at 15-minute intervals thereafter.
12. When primary power is returned to the building or facility, the time delay on retransfer to primary for each switch with a minimum setting of 5 minutes shall be recorded.
13. The time delay on the prime mover cool down period and shutdown shall be recorded.
14. Allow prime mover to cool for 5 minutes.
15. A load shall be applied for 4 hours total. The building load shall be permitted to serve as part or all of the load, supplemented by a load bank of sufficient size to provide a load equal to 100 percent of the nameplate rating of the Emergency Power Supply (EPS), less applicable derating factors for site conditions. Observe and record load changes and the resultant effect on voltage and frequency.
16. The full load test shall be initiated immediately after the cooling time has expired by any method that starts the prime mover and, immediately upon reaching rated rpm, picks up 100 percent of the nameplate kW rating on one step, less applicable derating factors for site conditions.
17. During test, record the following at 5-minute intervals for the first 15 minutes and every 15 minutes for the rest of the test:

    a. Kilowatts
    b. Amperes
    c. Voltage
    d. Frequency
    e. Coolant temperature
    f. Enclosure temperature (interior)
    g. Oil pressure
    h. Engine exhaust temperature

i. Engine inlet temperature
j. Oil Temperature
k. Battery charge rate

18. Upon completion of the test and after a cool down period, the crank/rest cycle shall be tested.

a. Any method recommended by the manufacturer for the cycle crank test shall be utilized to prevent the prime mover from running.
b. The control switch shall be set at "run" to cause the prime mover to crank.
c. The complete crank/rest cycle shall be observed and recorded.

19. Test alarm and shutdown circuits by simulating conditions.

E. Contractor shall fill fuel tanks upon completion of test.

F. Testing documentation shall be submitted to the Architect/Engineer for review and approval.

G. Generator testing worksheets are included with this specification section.

3.4 MANUFACTURER'S FIELD SERVICES

A. Prepare, start, test, and adjust systems under provisions of Section 26 05 00.

3.5 ADJUSTING

A. Adjust generator output voltage and engine speed.

3.6 CLEANING

A. Clean work under provisions of Section 26 05 00.

B. Clean engine and generator surfaces. Replace oil and fuel filters.

3.7 DEMONSTRATION

A. Provide systems demonstration. Coordinate the demonstration schedule with the Owner and Architect/Engineer.

B. Describe loads connected to emergency and standby systems and restrictions for future load additions.

C. Simulate power outage by interrupting normal source and demonstrate that system operates to provide emergency and standby power.

END OF SECTION 26 32 13

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SECTION 26 36 00 - TRANSFER SWITCH

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Automatic transfer switch and bypass/isolation switch ATS-#

B. Portable generator connection cabinet (GCC-#)

C. Remote annunciator for ATS RA-ATS-#

1.2 RELATED SECTIONS AND WORK

A. Refer to the Transfer Switch Schedule for rating and configuration.

1.3 QUALITY ASSURANCE

A. Manufacturer: Company specializing in automatic transfer equipment with three (3) years documented experience.

1.4 REFERENCES

A. NEMA ICS 1 - General Standards for Industrial Control and Systems

B. NEMA ICS 2 - Standards for Industrial Control Devices, Controllers, and Assemblies

C. NEMA ICS 6 - Enclosures for Industrial Controls and Systems

D. NEMA ICS 10 - Guide to Application of Low-Voltage Automatic Transfer Switch Equipment

E. UL 1008 - Standard for Automatic Transfer Switches

1.5 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 26 05 00.

B. Submit product data for transfer switches showing overall dimensions, electrical connections, electrical ratings, and environmental requirements.

C. Submit manufacturer's installation instructions under provisions of Section 26 05 00.

1.6 OPERATION AND MAINTENANCE DATA

A. Submit operation and maintenance data under provisions of Section 26 05 00.

B. Include instructions for operating equipment.

C. Include instructions for operating equipment under emergency conditions when engine generator is running.

D. Identify operating limits which may result in hazardous or unsafe conditions.

E. Document ratings of equipment and each major component.

F. Include routine preventive maintenance and lubrication schedule.

G. List special tools, maintenance materials, and replacement parts.

1.7 REGULATORY REQUIREMENTS

A. Conform to applicable code for emergency and standby electrical systems.

PART 2 - PRODUCTS

2.1 AUTOMATIC TRANSFER WITH DELAYED TRANSITION AND BYPASS/ISOLATION SWITCH

A. Acceptable Manufacturers:

1. Schneider Electric ASCO 7ATB Series
2. Caterpillar CBTS Series
3. Cummins BPTC Series

B. Description: NEMA ICS 2; automatic transfer switch with manual bypass switch.

C. Configuration: Draw-out type electrically-operated, mechanically-held transfer switch with manually-operated CONNECTED, TEST, and DISCONNECTED draw-out positions, and with mechanically-operated, mechanically-held transfer switch connected to bypass automatic switch.

D. Bypass Switch Ratings: Match automatic transfer switch for electrical ratings.

2.2 PORTABLE GENERATORCONNECTION CABINET (GCC-

A. Acceptable Manufacturers:

1. Foxfab FFCC Series
2. Berthold Electric Co
3. Power Temp Systems Inc
4. ESL Power Systems Triple Switch Series
5. Trystar

B. Pad mount, powder coat painted NEMA 3R housing with lockable door, 1600 amps, 600 volt. Color-coded cam-lock connectors. Submit product data and dimensioned drawings. Color selection by Architect.

1. Load Bank Cam Lock Receptacle: Female or male cable
2. Portable Generator Cam Lock Receptacle: Male or female cable
3. Cam Lock Configuration: Power flow from female to male; note ground / neutral configurations are opposite of phase conductors at the same connection location.

C. Kirk Key Interlock: Provide a kirk key interlock between the permeant generator and the temporary generator disconnect.

D. Three-way Manual Transfer Switch: Provide-three-way switch to allow flexible connection between; onsite generator and load bank, portable generator and load, onsite generator and load.

E. Generator Start Signals: Provide parallel generator start cabling from the transfer switches to the portable generator cabinet. Provide quick connect type connections for the generator start signals.

2.3 RATINGS

A. Refer to the electrical diagrams for the Withstand and Close Ratings WCR available interrupting capacity (AIC) at the transfer switch. The transfer switch shall be series rated with the equipment feeding the transfer switch. The series rating shall be the larger of the two Short Circuit Current Ratings SCCR values when the SCCR rating of the equipment feeding the normal and emergency sides of the transfer switch is not equal.

B. Series rating with upstream devices shall be allowed per UL-1008.

2.4 AUTOMATIC SEQUENCE OF OPERATION

A. Initiate Time Delay to Start Alternate Source Engine Generator: Upon initiation by normal source monitor.

B. Time Delay to Start Alternate Source Engine Generator: 0 to 10 seconds, adjustable.

C. Initiate Transfer Load to Alternate Source: Upon initiation by normal source monitor and permission by alternate source monitor.

D. Time Delay Before Transfer to Alternate Power Source: 0 to 30 seconds, adjustable.

E. Initiate Retransfer Load to Normal Source: Upon permission by normal source monitor.

F. Time Delay Before Transfer to Normal Power: 0 to 30 minutes, adjustable; bypass time delay in event of alternate source failure.

G. Time Delay Before Engine Shut Down: 0 to 30 minutes, adjustable, of unloaded operation.

2.5 ENCLOSURE

A. Enclosure: NEMA ICS 6; Type 1.

2.6 ACCESSORIES

A. Indicating Lights: Mount in cover of enclosure to indicate NORMAL SOURCE AVAILABLE, ALTERNATE SOURCE AVAILABLE, SWITCH POSITION.

B. Test Switch: Key operated or password protected switch. Mount in cover of enclosure to simulate failure of normal source.

C. Engine Start Signal: Rated 10 amps at 30VDC shall be provided to start the engine generator in the event of a normal source outage.

D. Remote Start Circuit Monitoring: Provide continuous monitoring of the generator start circuits. A failure shall initiate visual and audible alarms at the generator, remote annunciators, and start the generator.

E. Return to Normal Switch: Mount in cover of enclosure to initiate manual transfer from alternate to normal source.

F. Transfer Switch Auxiliary Contacts: 2 normally open; 2 normally closed indicating switch to normal source or emergency source.

G. Normal Source Monitor: Monitor each line of normal source voltage and frequency; initiate transfer when voltage drops below 85 percent or frequency varies more than 3 Hertz from rated nominal value, values shall be field adjustable.

H. Alternate Source Monitor: Monitor each line of alternate source voltage and frequency; inhibit transfer when voltage is below 85 percent or frequency varies more than 3 percent Hertz from rated nominal voltage, values shall be field adjustable.

I. Engine Exerciser: Start engine every 28 days. Run for 30 minutes before shutting down. Each event shall be configurable for Test with Load or Test Without Load. Bypass exerciser control if normal source fails during exercising period.

J. In-Phase Monitor: Inhibit transfer until source and load are within 30 electrical degrees.

K. Connect alarms and status monitoring to the building management system for remote monitoring.

L. Provide 2 N.O. and 2 N.C. isolated contacts to indicate:

1. Normal source available.
2. Emergency source available.
3. Exercise mode in operation.

M. Serial Communication Port: Two twisted pairs of shielded communication cable in conduit shall daisy chain all transfer switches with a remote annunciator.

N. Annunciators shall be located where shown on the drawings, as directed by the Owner. Extend conduit and wire as required by the manufacturer.

O. An adjustable emergency to normal pre-signal signal to elevator controller.

P. Metering Capabilities: The following metered readings shall be available at the local display.

1. Current, per phase RMS and neutral
2. Current unbalance %
3. Voltage, phase-to-phase and phase-to-neutral
4. Voltage unbalance %
5. Real power (KW), per phase and 3-phase total
6. Apparent power (KVA), per phase and 3-phase total
7. Reactive power (KVAR), per phase and 3-phase total
8. Power factor, 3-phase total & per phase
9. Frequency
10. Accumulated energy, (KWH, KVAH, and KVARH)
11. Demand, (KWH, KVA)

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that surfaces are ready to receive work.

B. Verify field measurements are as instructed by the manufacturer.

C. Verify that required utilities are available, in proper location, and ready for use.

D. Beginning of installation means acceptance of existing conditions.

3.2 CONTROL AND SIGNAL CABLING

A. Provide control and signal cabling per manufacturer recommendations for the following systems components:

1. Remote annunciator.
2. Elevator controller. Provide wiring to elevator controller for emergency source mode and emergency to normal pre-signal.
3. Generator start signal. The generator start signal cabling for the following transfer switches shall be fire protected for a minimum of 2 hours using an approved method:

    a. Emergency, legally required, optional standby transfer switches
    b. Approved Methods:

        1) Raceway or cable encased in a minimum of 2 inches of concrete cover.
        2) Listed fire resistive raceway / cable system.
        3) Raceway / cable is protected by a listed electrical circuit protective system.

3.3 INSTALLATION

A. Install in accordance with manufacturer's instructions.

END OF SECTION 26 36 00

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SECTION 26 41 00 - LIGHTNING PROTECTION SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Air terminals and interconnecting conductors

B. Grounding and bonding for lightning protection

1.2 PRODUCTS INSTALLED BUT NOT FURNISHED UNDER THIS SECTION

A. Section 26 05 26 - Grounding and Bonding

B. Section 26 43 00 - Surge Protection Devices

1.3 REFERENCES

A. ANSI/NFPA 780 - Lightning Protection Code

B. ANSI/UL 96 - Lightning Protection Components

C. UL 96A - Installation Requirements for Lightning Protection Systems

1.4 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 26 05 00.

B. Shop drawings shall indicate layout of air terminals, grounding electrodes, and bonding connections to structure, ground grid, and other metal objects. Include terminal, electrode, and conductor sizes, and connection and termination details. Include indications for use of raceway and type, data on how concealment requirements will be met, and calculations required by NFPA 780 for bonding of grounded and isolated metal bodies.

C. Product data shall show dimensions and materials of each component, and include indication of listing in accordance with ANSI/UL 96 or a nationally recognized testing laboratory.

D. Qualification data for firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include data on listing or certification by an NRTL or LPI.

E. Submit manufacturer's installation instructions under provisions of Section 26 05 00.

F. Certification, signed by Contractor, that roof adhesive for air terminals is approved by manufacturers of both the terminal assembly and the single-ply membrane roofing material.

G. Field inspection reports indicating compliance with specified requirements.

1.5 SYSTEM DESCRIPTION

A. Lightning Protection System: System protecting MSU Temple Hall, consisting of air terminals on roofs, roof-mounted mechanical equipment, and penthouse roofs;bonding of structure and other metal objects; grounding electrodes; and interconnecting conductors. Class I materials shall be used for systems on structures not exceeding 75 feet in height. Class II materials shall be used for systems on structures exceeding 75 feet in height above grade.

B. Performance Statement: This specification and the accompanying roof plans describe the minimum material quality, required features, and operational requirements of the system. These documents do not convey every air terminal, conductor, and connection that must be made. Based on the equipment described and the performance required of the system, as presented in these documents, the Vendor and the Contractor are solely responsible for determining all equipment and wiring required for a complete and operational system.

1.6 PROJECT RECORD DOCUMENTS

A. Submit project record documents under provisions of Section 26 05 00.

B. Accurately record actual locations of air terminals, grounding electrodes, bonding connections, and routing of system conductors.

C. Listing and Labeling: As defined in NFPA 780, "Definitions" Article.

1.7 QUALIFICATIONS

A. Manufacturer: Company specializing in lightning protection equipment with minimum three (3) years documented experience and a member of the Lightning Protection Institute or who is listed by a nationally recognized testing laboratory.

B. Installer: Authorized installer of manufacturer with minimum three (3) years documented experience and certified by the Lightning Protection Institute.

C. Listing and Labeling: As defined in NFPA 780, "Definitions" Article.

1.8 PRE-INSTALLATION CONFERENCE

A. Convene a pre-installation conference one week prior to commencing work of this Section.

1.9 SEQUENCING AND SCHEDULING

A. Coordinate work under provisions of Section 26 05 00.

B. Coordinate the work of this Section with exterior and interior finish installations. Coordinate painting of exposed conduits to match building finish with Architect.

C. Coordinate installation of lightning protection with installation of other building systems and components, including electrical wiring, supporting structures and building materials, metal bodies requiring bonding to lightning protection components, and building finishes.

D. Coordinate installation of air terminals attached to roof systems with roofing manufacturer and Installer.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Heary Brothers Lightning Protection Co., Inc

B. Thompson Lightning Protection

C. Harger Lightning Protection

D. Robbins Lightning, Inc

E. Erico International Corporation

F. Burndy Thermoweld

G. VFC Lightning Protection

2.2 MATERIALS

A. All materials shall be copper and/or copper-bronze. In locations where the system components are mounted on aluminum surfaces, aluminum materials shall be used to avoid electrolytic corrosion of dissimilar metals.

B. Components: In accordance with ANSI/UL 96 or nationally recognized testing laboratory.

C. Air Terminals: Solid, unless otherwise indicated. Provide air terminals with safety 3/4" sphere tip. Provide swivel adapters to plumb air terminals when mounting on sloping surfaces.

D. Grounding Rods: Copper clad steel.

E. Ground Plate: 18"x18"x0.032" Copper ground plate.

F. Connectors and Splicers: Bronze, unless otherwise indicated.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that surfaces are ready to receive work.

B. Verify that field measurements are as shown on the shop drawings.

C. Beginning of installation means installer accepts existing conditions.

3.2 PROTECTION OF SURROUNDING ELEMENTS

A. Protect elements surrounding work of this Section from damage or disfiguration.

3.3 INSTALLATION

A. Install in accordance with manufacturer's instructions.

B. Install in accordance with ANSI/NFPA 780, UL 96A, and LPI-175.

C. Install conductors with direct paths from air terminals to ground connections. Avoid sharp bends and narrow loops.

D. Conceal the following conductors:

1. System conductors.
2. Down conductors.
3. Interior conductors.
4. Conductors within normal view from exterior locations at grade within 200 feet of building.
5. Notify Architect/Engineer at least 48 hours in advance of inspection before concealing lightning protection components.

E. Cable Connections: Use approved exothermic-welded connections for all conductor splices and connections between conductors and other components, except those above single-ply membrane roofing.

F. Bond extremities of metal bodies exceeding 60 feet in vertical length to structural steel members.

G. Provide a ground ring electrode that meets or exceeds minimum requirements in NFPA 780.

1. Bond ground terminals to ground ring electrode.
2. Bond grounded metal bodies on building within 12 feet of ground to ground ring electrode.
3. Bond grounded metal bodies on building within 12 feet of roof to interconnecting loop at eave level or above.

H. Structures exceeding 60 feet in height: Bond lightning protection components with intermediate-level interconnection loop conductors to down conductors and other grounded media at maximum 60-foot intervals.

3.4 CORROSION PROTECTION

A. Do not combine materials that can form an electrolytic couple that will accelerate corrosion in the presence of moisture unless moisture is permanently excluded from junction of such materials.

B. Use conductors with protective coatings where conditions would cause deterioration or corrosion of conductors.

C. Bi-metal transition fittings shall be used when changing between aluminum and copper conductors.

3.5 FIELD QUALITY CONTROL

A. Field inspection and testing will be performed under provisions of Section 26 05 00.

B. Obtain the services of Underwriters' Laboratories, Inc. to provide inspection and certification of the lightning protection system under provisions of UL 96A to obtain a UL Master Label for system or UL Master Label certification for new areas of protection under provisions of UL 96A to obtain a UL Recertified Master Label for the entire system.

C. Install UL Master Label and attach to building at location directed by the Owner.

D. Provide an inspection by an inspector certified by LPI to obtain an LPI certification.

END OF SECTION 26 41 00

SECTION 26 43 00 - SURGE PROTECTION DEVICES

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This section describes materials and installation requirements for factory and field wired low voltage surge protection devices (SPD) for the protection of all AC electrical circuits. SPD equipment to be installed at designated service entrance equipment, distribution panels, electronic equipment, elevators, and receptacle devices.

1.2 QUALITY ASSURANCE

A. The specified unit shall be designed, manufactured, tested and installed in compliance with the above references. The unit shall be "Listed by Underwriters Laboratories" to UL 1449.

B. Each unit shall be designed and manufactured by a qualified manufacturer of power conditioning equipment. The qualified manufacturer must have been engaged in the design and manufacturer of such products for a minimum of five years.

1.3 REFERENCES

A. ANSI/IEEE C62.33 - IEEE Guide on Testing of MOV components

B. ANSI/IEEE C62.35 - IEEE Guide on Testing of SAD components

C. ANSI/IEEE C62.41 - IEEE Recommended Practice on Surge Voltage in Low Voltage AC Power Circuits

D. ANSI/IEEE C62.45 - IEEE Guide on Surge Testing for Equipment Connected to Low Voltage AC Power Circuits

E. ANSI/UL 1449 Latest Edition - UL Standard for Safety for Surge Protective Devices

F. CBEMA - Computer Business Equipment Manufacturers Association

G. IEC 664 - International Engineering Consortium, Standard for Clamping Voltage

H. NFPA 70 - National Electrical Code (NEC)

I. UL 67 - Listed for Internal Panelboard Transient Voltage Surge Suppressors

J. UL 96A - Devices listed as approved for secondary surge arrestors (VZCA)

K. UL 248-1 - Fusing

L. UL 1283 - Electromagnetic Interference Filters, Fifth Edition

1.4 SUBMITTALS

A. Shop Drawings: Should include device dimensions, mounting requirements including wire size and over-current protection device rating, nameplate nomenclature, electrical ratings, short circuit current rating, and test results as indicated below under "Testing, Warranty and Life Expectancy" as provided by an independent test lab or a UL certified test lab for the category(ies) of suppression device(s) specified using the appropriate IEEE test wave. Product data sheets with installation instructions for each size and type of device are required. Shop drawings submitted without the testing data as required by section this section will be rejected.

B. Fuse information: Provide fuse information if required for operation. Include size, manufacturer, time-current chart responses to UL 1449 testing requirements, maximum surge protection capability per mode and phase as limited by the fuse, and verification of repetitive surge protection device operation without system degeneration greater than 10%.

1.5 SPARE PARTS

A. Surge Protection Modules: Furnish 1 replacement module for each type installed.

B. Fuses: Furnish to the Owner 3 spare fuses of each type and rating installed.

1.6 TESTING, WARRANTY AND LIFE EXPECTANCY

A. Manufacturer must provide independent testing on repetitive capability and maximum surge current rating of service entrance suppressor units. This shall be performed at a nationally recognized lab not affiliated with the manufacturer.

1. Single pulse surge current capacity: Single pulse surge current tested in a mode at rated surge currents.
2. Single pulse surge current capacity test: An initial UL 1449 defined 1.2 x 50µs, 6000V open circuit voltage waveform and an 8 x 20µs, 500A and 3kA short circuit current waveform shall be applied to benchmark the unit's suppression voltage (VPR).
3. A single 8 x 20µs waveform pulse of maximum rated surge current per mode shall then be applied. To complete the test, another UL 1449 surge shall be applied to verify the unit's survival. Survival is achieved if the suppression voltage measured from the two UL1449 surges does not vary by more than 10%.

B. Minimum Repetitive Surge Current Capacity:

1. Service entrance suppressor units should be tested repetitively at an independent lab to verify repetitive capacity.
2. Minimum Repetitive Surge Current Capacity Test:

a. An initial UL 1449 surge defined as 1.2 x 50µs, 6000V open circuit voltage waveform and an 8 x 20µs, 500A and 3kA short circuit current waveform shall be applied to benchmark the unit's suppression voltage.
b. A repetitive number of ANSI/IEEE C62.41.2-2002 (Category C3) surges, defined as a 1.2 x 50µs 10kV or 20kV open circuit voltage waveform and an 8 x 20µs 10,000A short circuit current waveform, shall then be applied at one-minute intervals.
c. To complete the test, another UL 1449 surge shall be applied to verify the unit's survival.

3. Survival is achieved if the suppression voltage (VPR) does not vary by more than 10%.
4. Proof of such testing shall be the test log generated by the surge generator.

C. Provide UL 1449 classification white sheet pages indicating the VPR (voltage protection rating) for each SPD unit submitted for this product using the 6kV/3kA combination wave surge.

D. Warranty: Ten (10) years. Includes workmanship, installation and programming.

E. No scheduled parts replacement or preventative maintenance shall be required.

PART 2 - PRODUCTS

2.1 DESCRIPTION

A. General: The unit shall provide transient voltage suppression, surge current diversion and high-frequency noise attenuation, when connected in parallel to the facilities distribution system. The unit MCOV shall not be less than 115% of the nominal system voltage. Operating frequency shall be for a 60 Hz system. The unit shall provide protection in all normal modes for "wye" and "delta" systems.

B. Short Circuit Current Rating: Provide factory label for SCCR rating. The short circuit current rating shall be the larger of the listed value on the drawings or as required by the equipment protected.

2.2 RATINGS

A. SPD-Insert #; Service Entrance Suppressors:

1. For 277/480-volt, 3 phase, 4 wire, type 2, category C3 unit.

   a. Surge current capacity: 100,000/200,000 amps per protection mode/phase
   b. Nominal Discharge Current: 20 kA.
   c. Mounting: Refer to the drawings.
   d. Voltage Protection Rating: Refer to requirements below.
   e. Components: Minimum component size of 20mm thermally protected metal oxide varistors (MOV).
   f. Disconnect: Surge-rated disconnect with 200,000 SCCR.

2. Manufacturers:

   a. Square D Surgelogic EMA Series
   b. Siemens TPS3 Series
   c. Current Technology Current Guard Plus
   d. ASCO Power Technologies 400 Series
   e. LEA International LSS Series

B. SPD-Insert # Secondary Distribution Suppressors:

1. For 277/480-volt, 3 phase, 4 wire, type 2, category B3/C1 unit.

   a. Surge current capacity: 100,000/200,000 amps per protection mode/phase
   b. Nominal Discharge Current (IN): 20 kA.
   c. Mounting: Refer to the drawings.
   d. Voltage Protection Rating: Refer to requirements below.
   e. Components: Minimum component size of 20mm metal thermally protected oxide varistors (MOV).

2. Manufacturers:

   a. Square D Surgelogic EMA Series
   b. Siemens TPS3 Series
   c. Eaton SPD Series
   d. Current Technology Current Guard Plus
   e. ASCO Power Technologies 400 Series
   f. LEA International CFS Series

C. Receptacles:

1. For 120-volt, 1 phase, 3 wire, type 3, category A3 unit.

a. Surge current capacity (IN): 12,000 amps per protection mode.
b. Components: 20mm MOV
c. Maximum Continuous Operating Voltage: 150 Volts

2. Refer to Specification Section 26 27 26 for additional receptacle construction information.

D. Voltage Protection Rating:

1. Protection modes and UL 1449 voltage protection rating for surge suppression units per each mode (L-N, L-L, L-G, and N-G as appropriate).

a. 277/480 Volt, 3 phase, 4 wire.1200 Volt L-N, L-G, N-G and 1800 Volt L-L
b. 480 Volt, 3 phase, 3 wire. 2000 Volt L-G, L-L
c. 120/208 Volt, 3 phase, 4 wire. 700 Volt L-N, N-G, 800 Volt L-G and 1200 Volt L-L
d. 240 Volt, 3 phase, 3 wire. 1200 Volt L-G, L-L
e. 120/240 Volt, 3 phase, 4 wire. 700 Volt L-N, N-G, 800 Volt L-G and 1200 Volt L-L

E. EMI/RFI Noise Rejection or Filtering:

1. Each unit shall include a UL1283 first order, high-frequency filter for noise filtering between 10 KHz and 100 MHz.

F. Indication:

1. Each unit shall include solid-state indicators with externally mounted LED visual status indicators that indicate on-line status of each protection mode of the unit.
2. Each unit shall include an audible alarm with silencing switch to indicate when protection has failed.
3. Provide each secondary distribution type unit(s) with a transient counter.
4. Each unit shall contain form "C" contacts for remote indication of an alarm status.

G. Fuses:

1. Use fuses recommended by the manufacturer to satisfy repetitive UL 1449 operation of the surge suppression unit.
2. Fuses shall be rated 200, 000 AIC minimum interrupting capacity.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine equipment for size and type of surge protection device to be used to ensure physical compatibility.

B. Inspect surge protection device for any signs of physical damage due to shipping or handling before installing surge protection device.

3.2 INSTALLATION

A. Mounting Location:

1. The unit shall be installed as close as practical to the panel and transformer secondary lugs in accordance with applicable national/Local Electrical Codes and the manufacturer's recommended installation instructions. Connect the unit to the transformer or switchboard or panel using a conduit nipple. Flush mount the unit in the front of the switchboard. Mount unit directly across from the breaker or disconnect serving it.
2. Integral surge protection devices mount between the main and branch circuit breakers.
3. If internal surge protection device is specified, device shall be installed in a barrier compartment isolated from other components.

B. Connections:

1. Conductors from the protected bus to the unit shall not be any longer than necessary avoiding unnecessary bends. The conductor leads shall be twisted together and as short as possible. Connection shall be with mechanical lugs for each phase, neutral, and ground if applicable. Contractor shall provide wire and circuit breakers sized per the approved manufacturer's requirements. Maximum lead length from protected bus to surge protection device shall be per manufacturer's requirements, but no greater than 5'-0".
2. The surge protection unit shall be isolatable from the electrical distribution system via 3 pole circuit breaker mounted in the switchboard/panelboard or be equipped with a factory supplied integral fused switch or circuit breaker. Single phase 120-volt units shall be hardwired without a disconnecting means.
3. Neutral and ground shall not be bonded together at secondary panelboard locations.

C. Additional Locations: Critical Load Protection - Fixed Equipment (120 Vac):

1. Install an A3 hard-wired surge protection device between each of the following equipment items and its power supply conductors.

   a. Fire alarm master panel
   b. Phone switch
   c. Intercom master
   d. Building management system master
   e. Security system master
   f. Telephone switch
   g. TV head
   h. Elevator control panel

D. General:

1. Check unit for proper operation of protection and indication under start-up.
2. Check unit to ensure all MOVs for each mode of protection are operational. Verify integral fuse links are operational and have not melted.
3. Surge suppression devices shall not be installed ahead of the main service disconnect(s).
4. Install fuses in all fuse holders and fused disconnects internal to the surge protection unit. Use fuses recommended by the manufacturer to satisfy repetitive UL 1449 operation of the surge suppression unit. External fusing of the surge protection device is not allowed.
5. Coordinate location of surge protection device to allow adequate clearances for maintenance.
6. Manufacturer service phone number shall be posted on the front of the surge protection device.

END OF SECTION 26 43 00

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SECTION 26 51 19 - LED LIGHTING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Interior luminaires and accessories

B. Exterior luminaires and accessories

C. Light-emitting diode (LED) luminaire systems

D. LED emergency lighting units

E. Emergency exit signs

1.2 RELATED SECTIONS

A. The lighting system design includes a combination of luminaire sources, lighting control components, programming sequences, and supplementary components for building and energy code compliance. The design uses performance-based specifications for portions of the lighting system to account for the limitation of comparable product solutions available by competitive manufacturers. The Contractor shall reference related specification sections, plans, schedules, and details prior to submitting pricing, submittals, and installation. The Contractor shall coordinate system component compatibility among various manufacturers and suppliers for a turnkey lighting system. Referenced sections include, but are not limited to, the following:

1. 26 09 33 Lighting Control Systems
2. Electrical drawings: Plans, luminaire schedules, lighting control sequence of operations, diagrams, and details.

1.3 REFERENCES

A. ANSI C78.377 - Specifications for the Chromaticity of Solid State Lighting Products

B. ANSI C82.16 - Light-Emitting Diode Drivers - Method of Measurement

C. ANSI C82.77 - Standard for Harmonic Emission Limits and Related Power Quality Requirements for Lighting Equipment

D. NFPA 70E - National Electrical Safety Code

E. NEMA SSL1 - Electronic Drivers for LED Devices, Arrays or System

F. UL 8750 - Light Emitting Diode (LED) Equipment for use in Lighting Products

G. LM-79 - Approved Method: Electrical and Photometric Measurements of Solid-State Lighting Products

H. LM-80 - Measuring Luminous Flux and Color Maintenance of LED

I. FS W-L-305 - Light Set, General Illumination (Emergency or Auxiliary)

J. UL 924 - Standard for Emergency Lighting and Power Equipment

1.4 SUBMITTALS

A. Submit product data under provisions of Section 26 05 00.

B. Basic Requirements of Submittal:

1. Submit product data sheets for luminaires, LED light engines, drivers and poles. Include complete product model number with all options as specified. Submittal shall be arranged with luminaires listed in ascending order, and with each luminaire's, LED light engine, driver, or pole information following luminaire's product data. Failure to organize submittal in this manner will result in the submittal being rejected.
2. Submit lens product data, dimensions and weights if not included in product data sheet submittal.
3. Include outline drawings, support points, weights, and accessory information for each luminaire.
4. Submit manufacturer origin of LED chipset and driver.

C. LED Lighting - Performance Testing Submittal (when requested by Architect/Engineer):

1. IESNA LM-79: Include photometric report for the latest generation system being furnished. Provide name of independent testing laboratory, report number, date of test, luminaire series/model number, input wattage, and light source specifications.
2. IESNA LM-80: Measuring Lumen Maintenance of LED Light Sources.

D. LED Lighting - Control Compatibility Submittal:

1. Submit lighting control capability data for each LED luminaire. The submittal shall clearly identify device data proposed by the Contractor and approved by the luminaire manufacturer for dimming, switching, addressable, wireless, and similar control characteristics.

E. Submit Design Lights Consortium (DLC) information for each luminaire type.

F. Submit utility rebate forms where offered at project location. Submit completed rebate forms within 30 days of Substantial Completion.

1.5 EXTRA STOCK

A. Provide extra stock under provisions of Section 26 05 00.

B. LED Light Engines or Modules: Insert5percent of quantity installed, minimum one (1) of each size and type of field replaceable light engine or module. Provide field replacement installation instructions.

C. Lenses: Three (3) percent of quantity installed, minimum one (1) of each size and type.

D. LED Drivers: Insert5percent of quantity installed, minimum one (1) of each size and type.

E. Exit Signs: Provide Insert3additional exit sign luminaires complete with labor, conduit, and wire. Additional exit luminaires shall be located per the Architect/Engineer or provided as attic stock when a location is not defined prior to Owner occupancy. When multiple exit signs are scheduled, the quantity listed above shall represent each type listed.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site. Store and protect under provisions of Section 26 05 00.

B. Protect luminaire finishes, lenses, and trims from damage during storage and installation. Do not remove protective films until construction cleanup within each area is complete.

C. Handle site lighting poles carefully to prevent breakage and damage to finish.

1.7 WARRANTY

A. The warranty period begins at the date of Substantial Completion.

B. LED Light Engines and Drivers:
1. LED Drivers and Dimming Drivers: Five (5) years
2. Light Emitting Diode (LED) Light Engines: Five (5) years

C. Emergency Lighting Units and Exit Signs:

1. Emergency Lighting Units: Three (3) year, non-prorated
2. Exit Signs: Three (3) year, non-prorated
3. Emergency Unit and Exit Sign Battery: Sealed lead acid or lead calcium cell, requiring no maintenance or replacement for ten (10) years under normal conditions.

D. Automatic Load Control Relay (ALCR): Five (5) year

1.8 REGULATORY REQUIREMENTS

A. Conform to NFPA 101 for installation requirements

PART 2 - PRODUCTS

2.1 INTERIOR LUMINAIRES AND ACCESSORIES - GENERAL

A. Lensed Troffers: Provide hinged frames with latches and 0.125-inch thick virgin acrylic lenses. Prismatic lenses shall have depth of no less than 0.080", KSH12 or equal. Other lenses as scheduled.

B. Recessed Luminaires: Confirm ceiling and wall type and furnish trim and accessories necessary to permit proper installation in each system. Where fire-rated ceiling or wall assemblies are specified, furnish and install listed enclosures around luminaires that maintain the system rating.

C. Luminaires: Louvers shall be anodized low iridescent specular aluminum with mitered corners and interlocking construction.

D. Suspended Luminaires: Coordinate power feed and suspension canopies with ceiling type and architectural RCP for proper fit and location. Ensure finished installations are plumb and level at elevations specified. Verify suspension length prior to submittal.

E. Painted reflector surfaces shall have a minimum reflectance of 90%.

F. All painted components shall be painted after fabrication.

2.2 EXTERIOR LUMINAIRES AND ACCESSORIES - GENERAL

A. Listed for wet or damp location as scheduled. Provide ingress protection (IP) rating when scheduled.

B. Provide low temperature LED drivers, with reliable starting to -20°F.

C. In-grade luminaires shall have lamp/optic separation to prevent surface temperature from exceeding 115°F. Compartment separation of wire entry and control gear/lamp chamber.

D. Exterior LED luminaires shall contain separate, easily accessible and replaceable Category C surge protection device.

2.3 LIGHT EMITTING DIODE (LED) LUMINAIRE SYSTEMS

A. Refer to the luminaire schedule for color temperature and minimum color rendering index CRI requirements. Provide light source color consistency by utilizing a binning tolerance within a maximum 3-step McAdam ellipse unless noted otherwise.

B. LED chip arrays specified as color changing shall have chip colors as noted on the luminaire schedule.

C. Rated life shall be minimum of 50,000 hours at L70.

D. LED chips shall be wired so that failure of one chip does not prohibit operation of the remainder of the chip array.

E. Luminaire delivered lumens is defined as the absolute lumens per the manufacturers LM-79-08 test report.

F. LED luminaires shall be designed for ease of component replacement including modular replaceable boards or Zhaga sockets. Luminaires that are factory sealed and do not have field replaceable parts shall provide a 10-year warranty.

G. LED light engine shall have a maximum LLD of 0.85 at 50,000 hours at 25°C ambient.

H. LED Driver:

1. Solid state driver with integral heat sink. Driver shall have over-heat, short-circuit and overload protection, power factor 0.90 or above and maximum total harmonic distortion of 10%. Driver shall have a voltage fluctuation tolerance of +/- 10%.
2. Drivers shall have dimming capabilities as outlined in the luminaire schedule for each luminaire type. Dimming shall control light output in a continuous curve from 100% to 10% unless noted otherwise.
3. Driver shall have a minimum of 50,000 hours rated life.
4. Driver shall be tested to ANSI C82-16 for input current inrush, total harmonic distortion (THD), and power factor. Driver start time shall be less than 0.5 seconds to 98% of initial light output. Flicker should be less than 30% throughout the operating range.
5. Driver shall be field replaceable without removal of the luminaire.
6. Class A sound rating; inaudible in a 27 dBA ambient.
7. Demonstrate no visible change in light output with a variation of plus or minus 10 percent change in line-voltage input.

2.4 LED EMERGENCY LIGHTING UNITS

A. Self-Powered Emergency Lighting Units: One-piece, self-contained unit with sealed, maintenance-free nickel cadmium battery, automatic charger and electronic circuitry. Relay automatically energizes lamp from battery when circuit voltage drops to 80 percent of nominal voltage or below. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.

B. Battery: Maintenance free lead calcium type, with 90 minute capacity to supply the connected lamp load.

C. Charger: Dual-rate solid state current limiting charger, capable of maintaining the battery in a full-charge state during normal conditions, and capable of recharging discharged battery to full charged within 168 hours. Low voltage disconnect to prevent deep discharge of battery.

D. LED Lamp Wattage: As scheduled on luminaire schedule.

E. Remote Lamps: Match LED lamps on unit.

F. Indicators: Provide lamps to indicate AC ON and RECHARGING.

G. Provide test switch to transfer unit from normal supply to battery supply.

H. Electrical Connection: Knockout for conduit connection.

I. Unit Voltage: Refer to luminaire schedule volts, AC.

J. Self-Diagnostics and Testing:

1. Unit shall be self-diagnostic with continuous monitoring of charger performance and battery voltage. Any malfunction of battery, charger, transfer circuit, or emergency lamps shall be detected and visually indicated.
2. Unit shall be programmed to exercise the battery and test emergency operation by performing a five-minute discharge/diagnostic cycle every six months. A manual test switch shall allow a five-minute discharge/diagnostic test at any time.

2.5 EMERGENCY EXIT SIGNS

A. Exit Signs: Stencil face, 6-inch high letters, directional arrows as indicated, universal mounting type as indicated on the drawings.

B. Directional Indicators: The directional indicator for exit signage shall be of a chevron type meeting all requirements of NFPA 101.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Securely fasten luminaires to the listed and labeled ceiling framing member by mechanical means such as bolts, screws, rivets or listed clips identified for use with the type of ceiling framing members. The architectural ceiling framing system may be used in lieu of independent support with prior written approval by the ceiling system manufacturer and Authority Having Jurisdiction (AHJ). Luminaires and wiring installed in fire-rated ceiling assemblies shall be independently supported for all applications.

1. Install recessed flanged luminaires to permit removal from below. Use manufacturer-supplied plaster frames and swing gate supports. Provide independent support as follows:

a. Luminaires less than 56 lbs: Provide a minimum of two (2) #12 gauge suspended ceiling support wires located on diagonal corners of the luminaires.
b. Luminaires 56 lbs or greater: Provide a minimum of four (4) #12 gauge suspended ceiling support wires located on diagonal corners of the luminaires. Support luminaire independent of the ceiling system.
c. Luminaires larger than eight square feet (8 ft2): Support luminaire independent of the ceiling system.

B. Do not fasten luminaire supports to piping, ductwork, mechanical equipment, or conduit, unless otherwise noted. Support wires shall be tightly wrapped (minimum of three turns within 3 inches of the connection) and sharply bend to prevent vertical movement.

C. Support suspended or pendant mounted luminaires independent of ceiling grid with adjustable stainless steel aircraft cables or per luminaire schedule mounting requirements. Suspension assembly and anchors shall be capable of supporting 300 pounds dead load at each suspension point.

D. Support wire used to independently support luminaires, raceways, and wiring systems shall be distinguishable from ceiling support systems by color (field paint), tagging or equivalent means.

E. Provide seismic bracing of luminaires per IBC Chapter 16. Design pendant luminaires on a component seismic coefficient (Cc) of 0.67. Design vertical supports with a factor of safety of 4.0. Contractor shall verify the Seismic Hazard Exposure Group and Performance Criteria Factor.

F. Adjust aimable luminaires to obtain lighting levels on objects and areas as directed to obtain desired lighting levels.

G. Recessed luminaires and other optical accessories shall remain in protective wraps or films until construction in area is complete and area has been cleaned.

3.2 CONSTRUCTION USE OF PROJECT LUMINAIRES

A. The Contractor shall provide temporary construction lighting per the requirements of Division 1.

B. The project luminaires shown on the construction documents shall not be used for temporary construction purposes without providing a plan for Owner approval that addresses energy and luminaire operating hours.

3.3 AUTOMATIC LOAD CONTROL RELAYS

A. Factory or field installation per manufacturer requirements.

B. Fire Alarm Override: Provide connection to addressable fire alarm relay.

3.4 RELAMPING

A. Replace failed LED light engine modules or arrays at completion of work.

3.5 ADJUSTING AND CLEANING

A. Align luminaires and clean lenses and diffusers at completion of work. Clean paint splatters, dirt, and debris from installed luminaires.

B. Touch up luminaire and pole finish at completion of work.

3.6 OWNER TRAINING

A. Test emergency lighting equipment for 60 minutes to determine proper operation, prior to Substantial Completion, with the Owner's Representative.

B. Provide electronic copy of periodic test log form to Owner's Representative. Explain and instruct Owner's Representative of requirements for testing and maintenance. Refer to latest adopted NFPA 101 for testing and logging requirements.

3.7 LUMINAIRE SCHEDULE

A. As shown on the drawings.

END OF SECTION 26 51 19

SECTION 27 05 00 - BASIC COMMUNICATIONS SYSTEMS REQUIREMENTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Basic Communications Systems Requirements specifically applicable to Division 27 sections, in addition to Division 1 - General Requirements.

B. All materials and installation methods shall conform to the applicable standards, guidelines and codes referenced herein and within each specification section.

1.2 SCOPE OF WORK

A. This Specification and the associated drawings govern furnishing, installing, testing and placing into satisfactory operation the Communications Systems.

B. The Contractor shall furnish and install all new materials as indicated on the drawings, and/or in these specifications, and all items required to make the portion of the Communications Work a finished and working system.

C. Separate contracts will be awarded for the following work. The division of work listed below is for the contractors' convenience and lists a normal breakdown of the work. Please refer to the Construction Manager's scope statements for complete scope of work description.

D. Description of Systems include, but are not limited to, the following:

1. Rough-in for Structured Cabling System including, but not limited to:
    a. Information outlets (IOs) excluding faceplates, jacks and labeling.
    b. Cabling pathways.
    c. Grounding and Bonding
2. Rough-in for Audio/Visual Systems.
3. Removal/demolition work and/or relocation and reuse of existing systems and equipment.
4. All associated electrical backboxes, conduit, miscellaneous cabling, and power supplies required for proper system installation and operation as defined in the "Suggested Matrix of Scope Responsibility".
5. Firestopping of penetrations as described in Division 7.

1.3 OWNER FURNISHED PRODUCTS

A. Cabling

B. Terminations

C. Equipment Racks

1.4 WORK SEQUENCE

A. All construction work that will produce excessive noise levels and interference with normal building operations, as determined by the Owner, shall be scheduled with the Owner. It may be necessary to schedule such work during non-occupied hours. The Owner shall reserve the right to set policy as to when restricted construction hours will be required.

1.5 DIVISION OF WORK BETWEEN ELECTRICAL AND COMMUNICATIONS CONTRACTORS

A. Division of work is the responsibility of the Prime Contractor. Any scope of work described in the contract document shall be sufficient for including said requirement in the project. The Prime Contractor shall be solely responsible for determining the appropriate subcontractor for the described scope. In no case shall the project be assessed an additional cost for scope that is described in the contract documents. The following division of responsibility is a guideline based on typical industry practice.

B. Definitions:

1. "Electrical Contractor" as referred to herein refers to the Contractors listed in Division 26 of this Specification.
2. "Electrical Contractor" shall also refer to the Contractor listed in Division 27 of this specification when the "Suggested Matrix of Scope Responsibility" indicates the work shall be provided by the EC. Refer to the Contract Documents for the "Suggested Matrix of Scope Responsibility".
3. "Technology Contractor" as referred to herein refers to the Contractors listed in Division 27 of this Specification.
4. Low Voltage Technology Wiring: The wiring (less than 120VAC) associated with the Technology Systems, used for analog and/or digital signals between equipment.
5. Telecommunications/Technology Rough-in: Relates specifically to the backboxes, necessary plaster rings and other miscellaneous hardware required for the installation and mounting of the telecommunications/technology outlet. Rough-in shall include conduit from the information outlet backbox to the nearest cable tray. Where surface mounted backboxes are required, conduit shall be routed to the nearest cable tray.

C. General:

1. The purpose of these specifications is to outline typical Electrical and Technology Contractor's work responsibilities as related to technology systems including telecommunications rough-in, audio/visual systems rough-in, conduit, cable tray, power wiring, and low voltage communications and technology wiring. The prime contractor is responsible for all divisions of work.
2. The exact wiring requirements for much of the equipment cannot be determined until the systems have been purchased and submittals are approved. Therefore, only known wiring, conduits, raceways, and electrical power as related to such items, is shown on the technology drawings. Other wiring, conduits, raceways, junction boxes, and electrical power not shown on the technology drawings but required for the successful operation of the systems shall be the responsibility of the Technology Contractor and included in the Contractor's bid.
3. Where the Electrical Contractor is required to install conduit, conduit sleeves and/or power connections in support of technology systems, the final installation shall not begin until a coordination meeting between the Electrical Contractor and the Technology Contractor has convened to determine the exact location and requirements of the installation.
4. Where the Electrical Contractor is required to install cable tray that will contain low voltage technology wiring, the installation shall not begin until the Technology Contractor has completed a coordination review of the cable tray shop drawing.
5. This Contractor shall establish electrical and technology utility elevations prior to fabrication and installation. The Technology Contractor shall cooperate with the Electrical Contractor and the determined elevations in accordance with the guidelines below. This Contractor shall coordinate utility elevations with other trades. When a conflict arises, priority shall be as follows:

   a. Lighting Fixtures
   b. Gravity Flow Piping, including Steam and Condensate
   c. Sheet Metal
   d. Electrical Busduct

e. Cable Trays, including 12" access space
f. Sprinkler Piping and other Piping
g. Conduit and Wireway
h. Open Cabling

D. Electrical Contractor's Responsibility:

1. Assumes all responsibility for all required conduit and power connections when shown on the "Suggested Matrix of Scope Responsibility" to be provided by the Electrical Contractor.
2. Assumes all responsibility for providing and installing cable tray.
3. Responsible for Communications Systems grounding and bonding.
4. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

E. Technology Contractor's Responsibility:

1. Assumes all responsibility for the low voltage technology wiring of all systems, including cable support where open cable is specified.
2. Assumes all responsibility for all required backboxes, conduit and power connections not specifically shown as being provided by the Electrical Contractor on the "Suggested Matrix of Scope Responsibility."
3. Assumes all responsibility for providing and installing all ladder rack and other cable management hardware (as defined herein).
4. Responsible for providing the Electrical Contractor with the required grounding lugs or other hardware for each piece of technology equipment which is required to be bonded to the technology bonding system.
5. This Contractor is responsible for coordination of utilities with all other Contractors. If any field coordination conflicts are found, the Contractor shall coordinate with other Contractors to determine a viable layout.

1.6 COORDINATION DRAWINGS

A. Definitions:

1. Coordination Drawings: A compilation of the pertinent layout and system drawings that show the sizes and locations, including elevations, of system components and required access areas to ensure that no two objects will occupy the same space.

   a. Mechanical trades shall include, but are not limited to, mechanical equipment, ductwork, fire protection systems, plumbing piping, medical gas systems, hydronic piping, steam and steam condensate piping, and any item that may impact coordination with other disciplines.
   b. Electrical trades shall include, but are not limited to, electrical equipment, conduit 1.5" and larger, conduit racks, cable trays, pull boxes, transformers, raceway, busway, lighting, ceiling-mounted devices, and any item that may impact coordination with other disciplines.
   c. Technology trades shall include, but are not limited to, technology equipment, racks, conduit 1.5" and larger, conduit racks, cable trays, ladder rack, pull boxes, raceway, ceiling-mounted devices, and any item that may impact coordination with other disciplines.
   d. Maintenance clearances and code-required dedicated space shall be included.
   e. The coordination drawings shall include all underground, underfloor, in-floor, in chase, and vertical trade items.

2. Spaces with open/cloud ceiling architecture shall indicate the overhead utilities and locate equipment as required to maintain clearance above lights. The intent for the installation is to maintain a maximum allowable vertical clearance and an organized/clean manner in the horizontal. Notify Architect/Engineer of the maximum clearance which can be maintained. Failure to comply will result in modifications with no cost to Owner.
3. The contractors shall use the coordination process to identify the proper sequence of installation of all utilities above ceilings and in other congested areas, to ensure an orderly and coordinated end result, and to provide adequate access for service and maintenance.

B. Participation:

1. The contractors and subcontractors responsible for work defined above shall participate in the coordination drawing process.
2. One contractor shall be designated as the Coordinating Contractor for purposes of preparing a complete set of composite electronic CAD coordination drawings that include all applicable trades, and for coordinating the activities related to this process. The Coordinating Contractor for this project shall be the Mechanical Contractor.

    a. The Coordinating Contractor shall utilize personnel familiar with requirements of this project and skilled as draftspersons/CAD operators, competent to prepare the required coordination drawings.

3. Electronic CAD drawings shall be submitted to the Coordinating Contractor for addition of work by other trades. IMEG will provide electronic file copies of ventilation drawings for contractor's use if the contractor signs and returns an "Electronic File Transfer" waiver provided by IMEG. IMEG will not consider blatant reproductions of original file copies an acceptable alternative for coordination drawings.

C. Drawing Requirements:

1. The file format and file naming convention shall be coordinated with and agreed to by all contractors participating in the coordination process and the Owner.

    a. Scale of drawings:

        1) General plans: 1/4 Inch = 1'-0" (minimum).
        2) Mechanical, electrical, communication rooms, and including the surrounding areas within 10 feet: 1/2 Inch = 1'-0" (minimum).
        3) Shafts and risers: 1/2 Inch = 1'-0" (minimum).
        4) Sections of shafts and mechanical and electrical equipment rooms: 1/4 Inch = 1'-0" (minimum).
        5) Sections of congested areas: 1/2 Inch = 1'-0" (minimum).

2. Ductwork layout drawings shall be the baseline system for other components. Ductwork layout drawings shall be modified to accommodate other components as the coordination process progresses.
3. There may be more drawings required for risers, top and bottom levels of mechanical rooms, and shafts.
4. The minimum quantity of drawings will be established at the first coordination meeting and sent to the A/E for review. Additional drawings may be required if other areas of congestion are discovered during the coordination process.

D. General:

1. Coordination drawing files shall be made available to the A/E and Owner's Representative. The A/E will only review identified conflicts and give an opinion, but will not perform as a coordinator.
2. A plotted set of coordination drawings shall be available at the project site.
3. Coordination drawings are not shop drawings and shall not be submitted as such.
4. The contract drawings are schematic in nature and do not show every fitting and appurtenance for each utility. Each contractor is expected to have included in his/her bid sufficient fittings, material, and labor to allow for adjustments in routing of utilities made necessary by the coordination process and to provide a complete and functional system.
5. The contractors will not be allowed additional costs or time extensions due to participation in the coordination process.
6. The contractors will not be allowed additional costs or time extensions for additional fittings, reroutings or changes of duct size, that are essentially equivalent sizes to those shown on the drawings and determined necessary through the coordination process.
7. The A/E reserves the right to determine space priority of equipment in the event of spatial conflicts or interference between equipment, piping, conduit, ducts, and equipment provided by the trades.

8. Changes to the contract documents that are necessary for systems installation and coordination shall be brought to the attention of the A/E.
9. Access panels shall preferably occur only in gypsum board walls or plaster ceilings where indicated on the drawings.

   a. Access to mechanical, electrical, technology, and other items located above the ceiling shall be through accessible lay-in ceiling tile areas.
   b. Potential layout changes shall be made to avoid additional access panels.
   c. Additional access panels shall not be allowed without written approval from the A/E at the coordination drawing stage.
   d. Providing additional access panels shall be considered after other alternatives are reviewed and discarded by the A/E and the Owner's Representative.
   e. When additional access panels are required, they shall be provided without additional cost to the Owner.

10. Complete the coordination drawing process and obtain signoff of the drawings by all contractors prior to installing any of the components.
11. Conflicts that result after the coordination drawings are signed off shall be the responsibility of the contractor or subcontractor who did not properly identify their work requirements, or installed their work without proper coordination.
12. Updated coordination drawings that reflect as-built conditions may be used as record documents.

1.7 QUALITY ASSURANCE

A. Telecommunications Structured Cabling System Standards:

1. All work and equipment shall conform to the most current ratified version of the following published standards unless otherwise indicated that draft standards are to be followed:

   a. ANSI/NECA/BICSI 568 - Standard for Installing Commercial Building Telecommunications Cabling
   b. ANSI/TIA-568-C.0 - Generic Telecommunications Cabling for Customer Premises

      1) C.1 - Commercial Building Telecommunications Standard
      2) C.2 - Balanced Twisted-Pair Telecommunications Cabling and Components Standard
      3) C.3 - Optical Fiber Cabling Components Standard
      4) C.4 - Broadband Coaxial Cabling and Components Standard

   c. ANSI/TIA-569-C - Telecommunications Pathways and Spaces
   d. ANSI/TIA-606-B - Administration Standard for Commercial Telecommunications Infrastructure
   e. ANSI/TIA-607-B - Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
   f. ANSI/TIA/EIA-598-C - Optical Fiber Cable Color Coding
   g. NFPA 70 (NEC) - National Electrical Code (Current Edition)
   h. UL 444 - Standard for Safety for Communications Cable

B. Refer to individual sections for additional Quality Assurance requirements.

C. Qualifications:

1. Only products of reputable manufacturers as determined by the Architect/Engineer will be acceptable.
2. The installing Contractor shall be <u>certified</u> by the manufacturer of the structured cabling system. Documentation of certification is required at the time of bid. Shop drawings will not be approved until proof of certification is submitted. Refer to the end of this specification section for certification documentation requirements.

3. Each Contractor and their subcontractors shall employ only workers who are skilled in their respective trades and fully trained. All workers involved in the termination of cabling shall be individually certified by the manufacturer.
4. The Contractor shall be experienced in all aspects of this work and shall be required to demonstrate direct experience on recent systems of similar type and size.
5. The Contractor shall own and maintain tools and equipment necessary for successful installation and testing of optical and copper structured cabling systems and have personnel adequately trained in the use of such tools and equipment.

D. Compliance with Codes, Laws, Ordinances:

1. Conform to all requirements of the City of Springfield, Missouri Codes, Laws, Ordinances and other regulations having jurisdiction.
2. Conform to all published standards of Missouri State University.
3. In the event there are no local codes having jurisdiction over this job, the current issue of the National Electrical Code shall be followed.
4. If there is a discrepancy between the codes and regulations having jurisdiction over this installation, and these specifications, Architect/Engineer shall determine the method or equipment used.
5. If the Contractor notes, at the time of bidding, any parts of the drawings and specifications which are not in accordance with the applicable codes or regulations, he shall inform the Architect/Engineer in writing, requesting a clarification. If there is insufficient time to follow this procedure, he shall submit with the proposal, a separate price required to make the system shown on the drawings comply with the codes and regulations.
6. Verify the installation environment prior to purchasing or installing any cable. Cable installed in a plenum environment shall be appropriately rated. Bring all discrepancies between the contract documents and installation conditions to the attention of the Architect/Engineer prior to purchase or installation.
7. All changes to the system made after the letting of the contract, in order to comply with the applicable codes or the requirements of the Inspector, shall be made by the Contractor without cost to the Owner.

E. Permits, Fees, Taxes, Inspections:

1. Procure all applicable permits and licenses.
2. Abide by all applicable laws, regulations, ordinances, and other rules of the State or Political Subdivision wherein the work is done, or as required by any duly constituted public authority.
3. Pay all applicable charges for such permits or licenses that may be required.
4. Pay all applicable fees and taxes imposed by the State, Municipal and/or other regulatory bodies.
5. Pay all charges arising out of required inspections due to codes, permits, licenses or as otherwise may be required by an authorized body.
6. Pay all charges arising out of required contract document reviews associated with the project and as initiated by the Owner or authorized independent agency/consultant.
7. Pay any charges by the service provider related to the service or change in service to the project.
8. All equipment and materials shall be as approved or listed by the following (unless approval or listing is not applicable to an item by all acceptable manufacturers):

   a. Factory Mutual
   b. Underwriters' Laboratories, Inc.

F. Examination of Drawings:

1. The drawings for the technology systems work are diagrammatic, intended to convey the scope of the work and to indicate the general arrangements and locations of equipment etc., and the approximate sizes of equipment.
2. Contractor shall determine the exact locations of equipment and the exact routing of cabling to best fit the layout of the job. Scaling of the drawings will not be sufficient or accurate for determining this layout. Where a specific route is required, such route will be indicated on the drawings.
3. Where job conditions require reasonable changes in indicated arrangements and locations, such changes shall be made by the Contractor at no additional cost to the Owner.
4. If an item is either shown on the drawings, called for in the specifications or required for proper operation of the system, it shall be considered sufficient for including same in this contract.

5. The determination of quantities of material and equipment required shall be made by the Contractor from the drawings. Schedules on the drawings and in the specifications are completed as an aid to the Contractor but where discrepancies arise, the greater number shall govern.
6. Where words "provide", "install", or "furnish" are used on the drawings or in the specifications, it shall be taken to mean, to furnish, install and terminate completely ready for operation, the items mentioned.

G. Electronic Media/Files:

1. Construction drawings for this project have been prepared utilizing Revit.
2. Contractors and Subcontractors may request electronic media files of the contract drawings and/or copies of the specifications. Specifications will be provided in PDF format.
3. Upon request for electronic media, the Contractor shall complete and return a signed "Electronic File Transmittal" form provided by IMEG. If the information requested includes floor plans prepared by others, the Contractor will be responsible for obtaining approval from the appropriate Design Professional for use of that part of the document.
4. The electronic contract documents can be used for preparation of shop drawings and as-built drawings only. The information may not be used in whole or in part for any other project.
5. The drawings prepared by IMEG for bidding purposes may not be used directly for ductwork layout drawings or coordination drawings.
6. The use of these CAD documents by the Contractor does not relieve them from their responsibility for coordination of work with other trades and verification of space available for the installation.
7. The information is provided to expedite the project and assist the Contractor with no guarantee by IMEG as to the accuracy or correctness of the information provided. IMEG accepts no responsibility or liability for the Contractor's use of these documents.

H. Field Measurements:

1. Before ordering any materials, this Contractor shall verify all pertinent dimensions at the job site and be responsible for their accuracy.
2. Field conditions that will result in telecommunications drops that exceed the length limitations identified in the contract documents shall be brought to the attention of the Architect/Engineer prior to installation. The cost of reworking cabling that is too long, that was not brought to the written attention of the Architect/Engineer will be borne entirely by the Contractor.
3. This Contractor shall provide the Architect/Engineer with written documentation of any cabling drops that will not be able to use the cable tray (where cable tray is available) due to the resulting cabling lengths. This documentation shall be submitted prior to installation and installation shall not commence until approved by the Architect/Engineer.

1.8 SUBMITTALS

A. Submittals shall be required for the following items, and for additional items where required elsewhere in the specifications or on the drawings.

1. Submittals list:

Referenced Specification Section	Submittal Item	Coordination Drawings
27 05 26	Communications Bonding	
27 05 28	Interior Communications Pathways	Yes
27 11 00	Communication Equipment Rooms	Yes

B. General Submittal Procedures: In addition to the provisions of Division 1, the following are required:

1. Transmittal: Each transmittal shall include the following:

a. Date

b. Project title and number
c. Contractor's name and address
d. Description of items submitted and relevant specification number
e. Notations of deviations from the contract documents
f. Other pertinent data

2. Submittal Cover Sheet: Each submittal shall include a cover sheet containing:

a. Date
b. Project title and number
c. Architect/Engineer
d. Contractor and subcontractors' names and addresses
e. Supplier and manufacturer's names and addresses
f. Description of item submitted (using project nomenclature) and relevant specification number
g. Notations of deviations from the contract documents
h. Other pertinent data
i. Provide space for Contractor's review stamps

3. Composition:

a. Submittals shall be submitted using specification sections and the project nomenclature for each item.
b. Individual submittal packages shall be prepared for items in each specification section. All items within a single specification section shall be packaged together where possible. An individual submittal may contain items from multiple specifications sections if the items are intimately linked (e.g., pumps and motors).
c. All sets shall contain an index of the items enclosed with a general topic description on the cover.

4. Content: Submittals shall include all fabrication, erection, layout, and setting drawings; manufacturers' standard drawings; schedules; descriptive literature, catalogs and brochures; performance and test data; wiring and control diagrams; dimensions; shipping and operating weights; shipping splits; service clearances; and all other drawings and descriptive data of materials of construction as may be required to show that the materials, equipment or systems and the location thereof conform to the requirements of the contract documents.
5. Contractor's Approval Stamp:

a. The Contractor shall thoroughly review and approve all shop drawings before submitting them to the Architect/Engineer. The Contractor shall stamp, date and sign each submittal certifying it has been reviewed.
b. Unstamped submittals will be rejected.
c. The Contractor shall review, stamp and approve all subcontractors' submittals as described above.
d. The Contractor's approval stamp is required on all submittals. Approval will indicate the Contractor's review of all material and a complete understanding of exactly what is to be furnished. Contractor shall clearly mark all deviations from the contract documents on all submittals. If deviations are not marked by the Contractor, then the item shall be required to meet all drawing and specification requirements.

6. Submittal Identification and Markings:

a. The Contractor shall clearly mark each item with the same nomenclature applied on the drawings or in the specifications.
b. The Contractor shall clearly indicate the size, finish, material, etc.
c. Where more than one model is shown on a manufacturer's sheet, the Contractor shall clearly indicate exactly which item and which data is intended.
d. All marks and identifications on the submittals shall be unambiguous.

7. Schedule submittals to expedite the project. Coordinate submission of related items.

8. Identify variations from the contract documents and product or system limitations that may be detrimental to the successful performance of the completed work.
9. Reproduction of contract documents alone is not acceptable for submittals.
10. Incomplete submittals will be rejected without review. Partial submittals will only be reviewed with prior approval from the Architect/Engineer.
11. Submittals not required by the contract documents may be returned without review.
12. The Architect/Engineer's responsibility shall be to review one set of shop drawing submittals for each product. If the first submittal is incomplete or does not comply with the drawings and/or specifications, the Contractor shall be responsible to bear the cost for the Architect/Engineer to recheck and handle the additional shop drawing submittals.
13. Submittals shall be reviewed and approved by the Architect/Engineer before releasing any equipment for manufacture or shipment.
14. Contractor's responsibility for errors, omissions or deviation from the contract documents in submittals is not relieved by the Architect/Engineer's approval.
15. Schedule shall allow for adequate time to perform orderly and proper review of submittals, including time for consultants and Owner if required, and resubmittals by Contractor if necessary, and to cause no delay in Work or in activities of Owner or other contractors.

    a. Allow at least two weeks for Architect's/Engineer's review and processing of each submittal.

16. Architect/Engineer reserves the right to withhold action on a submittal which, in the Architect/Engineer's opinion, requires coordination with other submittals until related submittals are received. The Architect/Engineer will notify the Contractor, in writing, when they exercise this right.

C. Electronic Submittal Procedures:

1. Distribution: Email submittals as attachments to all parties designated by the Architect/Engineer, unless a web-based submittal program is used.
2. Transmittals: Each submittal shall include an individual electronic letter of transmittal.
3. Format: Electronic submittals shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Submittals that are not legible will be rejected. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.
4. File Names: Electronic submittal file names shall include the relevant specification section number followed by a description of the item submitted, as follows. Where possible, include the transmittal as the first page of the PDF instead of using multiple electronic files.

    a. Submittal file name: 27 XX XX.description.YYYYMMDD
    b. Transmittal file name: 27 XX XX.description.YYYYMMDD

5. File Size: Files shall be transmitted via a pre-approved method. Larger files may require an alternative transfer method, which shall also be pre-approved.

1.9 PRODUCT DELIVERY, STORAGE, HANDLING & MAINTENANCE

A. Exercise care in transporting and handling to prevent damage to fixtures, equipment and materials.

B. Store materials on the site to prevent damage.

C. Keep fixtures, equipment and materials clean, dry and free from deleterious conditions.

1.10 WARRANTY

A. At a minimum, provide a one (1) year warranty for all equipment, materials, and workmanship. Individual specifications sections within Division 27 may require additional warranty requirements for specific equipment or systems.

B. The warranty period for the entire installation described in this Division of the specifications shall commence on the date of substantial completion unless a whole or partial system or any separate piece of equipment or component is put into use for the benefit of any party other than the installing contractor with prior written authorization. In this instance, the warranty period shall commence on the date when such whole system, partial system or separate piece of equipment or component is placed in operation and accepted in writing by the Owner or their representative.

C. Warranty requirements shall extend to correction, without cost to the final user, of all work and/or equipment found to be defective or nonconforming to the contract documents. The Contractor shall bear the cost of correcting all damage resulting from such defects or nonconformance with contract documents exclusive of repairs required as a result of improper maintenance or operation, or of normal wear as determined by the Architect/Engineer.

1.11 INSURANCE

A. Contractor shall maintain insurance coverage as set forth in Division 1 of these specifications.

1.12 MATERIAL SUBSTITUTION

A. Where several manufacturers' names are given, the first named manufacturer constitutes the basis for job design and establishes the equipment quality required.

B. Equivalent equipment manufactured by the other named manufacturers may be used. Contractor shall ensure that all items submitted by these other manufacturers meets all requirements of the drawings and specifications and fits in the allocated space. When using other listed manufacturers, the Contractor shall assume responsibility for any and all modifications necessary (including, but not limited to structural supports, electrical connections and rough-in, and regulatory agency approval, etc.) and coordinate such with other contractors. The Architect/Engineer shall make the final determination of whether a product is equivalent.

C. Any material, article or equipment of other unnamed manufacturers which will adequately perform the services and duties imposed by the design and is of a quality equal to or better than the material, article or equipment identified by the drawings and specifications may be used if approval is secured in writing from the Architect/Engineer via addendum. The Contractor bears full responsibility for the unnamed manufacturers equipment adequately meeting the intent of design. The Architect/Engineer may reject manufacturer at time of shop drawing submittal. The Contractor assumes all costs incurred by other trades on the project as a result of changes necessary to accommodate the offered material, equipment or installation method.

D. Should this Contractor be unable to secure approval from the Architect/Engineer for other unnamed manufacturers as outlined above, this Contractor may list voluntary add or deduct prices for alternate materials on the bid form. These items will not be used in determining the low bidder. Should a voluntary alternate material be accepted, This Contractor shall assume all costs that may be incurred as a result of using the offered material, article or equipment necessitating extra expense on This Contractor or on the part of other Contractors whose work is affected.

PART 2 - PRODUCTS

2.1 CABLE JACKET RATING

A. This project requires all cable jackets to carry a plenum rating.

2.2 Refer to individual sections.

PART 3 - EXECUTION

3.1 JOBSITE SAFETY

A. Neither the professional activities of the Architect/Engineer, nor the presence of the Architect/Engineer or his or her employees and subconsultants at a construction site, shall relieve the Contractor and any other entity of their obligations, duties and responsibilities including, but not limited to, construction means, methods, sequence, techniques or procedures necessary for performing, superintending or coordinating all portions of the work of construction in accordance with the contract documents and any health or safety precautions required by any regulatory agencies. The Architect/Engineer and his or her personnel have no authority to exercise any control over any construction contractor or other entity or their employees in connection with their work or any health or safety precautions. The Contractor is solely responsible for jobsite safety. The Architect/Engineer and the Architect/Engineer's consultants shall be indemnified and shall be made additional insureds under the Contractor's general liability insurance policy.

3.2 GENERAL INSTALLATION REQUIREMENTS

A. Installation of all conduit and cabling shall comply with Sections 26 05 33 and 26 05 13. Additional conduit requirements described within this Division shall be supplemental to the requirement described in Section 26 05 33. Should conflicts exist between the two Divisions the more stringent (more expensive material and labor) condition shall prevail until bidding addendum or construction clarification or RFI can be submitted and responded to. In no case shall the Contractor carry the least stringent condition in the pricing.

B. It is the Contractor's responsibility to survey the site and include all necessary costs to perform the installation as specified.

C. The Contractor shall be responsible for identifying and reporting to the Architect/Engineer any existing conditions including but not limited to damage to walls, flooring, ceiling and furnishings prior to start of work. All damage to interior spaces caused by this Contractor shall be repaired at this Contractor's expense to pre-existing conditions, including final colors and finishes.

D. All cables and devices installed in damp or wet locations, including any underground or underslab location, shall be listed as suitable for use in such environments. Follow manufacturer's recommended installation practices for installing cables and devices in damp or wet locations. Any cable or device that fails as a result of being installed in a damp or wet location shall be replaced at the Contractor's expense.

3.3 FIELD QUALITY CONTROL

A. General:

1. Refer to specific Division 27 sections for further requirements.
2. The Contractor shall conduct all tests required and applicable to the work both during and after construction of the work.
3. The necessary instruments and materials required to conduct or make the tests shall be supplied by the Contractor who shall also supply competent personnel for making the tests who has been schooled in the proper testing techniques.
4. In the event the results obtained in the tests are not satisfactory, This Contractor shall make such adjustments, replacements and changes as are necessary and shall then repeat the test or tests which disclose faulty or defective work or equipment, and shall make such additional tests as the Architect/Engineer or code enforcing agency deems necessary.
5. All communications cable tests that fail, including those due to excessive cabling lengths, shall be remedied by the Contractor without cost to the project.

B. Protection of cable from foreign materials:

1. It is the Contractor's responsibility to provide adequate physical protection to prevent foreign material application or contact with any cable type. Foreign material is defined as any material that would negatively impact the validity of the manufacturer's performance warranty. This includes, but is not limited, to overspray of paint (accidental or otherwise), drywall compound, or any other surface chemical, liquid or compound that could come in contact with the cable, cable jacket or cable termination components.
2. Application of foreign materials of any kind on any cable, cable jacket or cable termination component will not be accepted. It shall be the Contractor's responsibility to replace any component containing overspray, in its entirety, at no additional cost to the project. Cleaning of the cables with harsh chemicals is not allowed. This requirement is regardless of the PASS/FAIL test results of the cable containing overspray. Should the manufacturer and warrantor of the structured cabling system desire to physically inspect the installed condition and certify the validity of the structured cabling system (via a signed and dated statement by an authorized representative of the structured cabling manufacturer), the Owner may, at their sole discretion, agree to accept said warranty in lieu of having the affected cables replaced. In the case of plenum cabling, in addition to the statement from the manufacturer, the Contractor shall also present to the Owner a letter from the local Authority Having Jurisdiction stating that they consider the plenum rating of the cable to be intact and acceptable.

3.4 PROJECT CLOSEOUT

A. Refer to the Division 1 Section: PROJECT CLOSEOUT for requirements. The following paragraphs supplement the requirements of Division 1.

B. Final Jobsite Observation:

1. The Architect/Engineer will not perform a final jobsite observation until the project is ready. This is not dictated by schedule, but rather by completeness of the project.
2. Refer to the end of this specification section for a "STATEMENT INDICATING READINESS FOR FINAL JOBSITE OBSERVATION."
3. The Contractor shall sign this form and return it to the Architect/Engineer so that the final observation can commence.

C. Before final payment will be authorized, this Contractor must have completed the following:

1. Submitted operation and maintenance manuals to the Architect/Engineer for review.
2. Submitted bound copies of approved shop drawings.
3. Record documents including edited drawings and specifications accurately reflecting field conditions, <u>inclusive</u> of all project revisions, change orders, and modifications.
4. Submitted a report stating the instructions given to the Owner's representative complete with the number of hours spent in the instruction. The report shall bear the signature of an authorized agent of This Contractor and shall be signed by the Owner's representative as having received the instructions.
5. Submitted testing reports for all systems requiring final testing as described herein.
6. Submitted start-up reports on all equipment requiring a factory installation inspection and/or start.
7. Provide spare parts, maintenance, and extra materials in quantities specified in individual specification sections. Deliver to project site; submit receipt to Architect/Engineer prior to final payment being approved.
8. Provide System Assurance Warranty certificate for the telecommunications system.

3.5 OPERATION AND MAINTENANCE MANUALS

A. General:

1. Provide an electronic copy of the O&M manuals as described below for Architect/Engineer's review and approval. The electronic copy shall be corrected as required to address the Architect/Engineer's comments. Once corrected, electronic copies and paper copies shall be distributed as directed by the Architect/Engineer.
2. Approved O&M manuals shall be completed and in the Owner's possession prior to Owner's acceptance and at least 10 days prior to instruction of operating personnel.

B. Electronic Submittal Procedures:

1. Distribution: Email the O&M manual as attachments to all parties designated by the Architect/Engineer.
2. Transmittals: Each submittal shall include an individual electronic letter of transmittal.
3. Format: Electronic submittals shall be in PDF format only. Scanned copies, in PDF format, of paper originals are acceptable. Submittals that are not legible will be rejected. Do not set any permission restrictions on files; protected, locked, or secured documents will be rejected.
4. File Names: Electronic submittal file names shall include the relevant specification section number followed by a description of the item submitted, as follows. Where possible, include the transmittal as the first page of the PDF instead of using multiple electronic files.

    a. O&M file name: O&M.div27.contractor.YYYYMMDD
    b. Transmittal file name: O&Mtransmittal.div27.contractor.YYYYMMDD

5. File Size: Files shall be transmitted via a pre-approved method. Larger files may require an alternative transfer method, which shall also be pre-approved.
6. Provide the Owner with an approved copy of the O&M manual on compact discs (CD), digital video discs (DVD), or flash drives with a permanently affixed label, printed with the title "Operation and Maintenance Instructions", title of the project and subject matter of disc/flash drive when multiple disc/flash drives are required.
7. All text shall be searchable.
8. Bookmarks shall be used, dividing information first by specification section, then systems, major equipment and finally individual items. All bookmark titles shall include the nomenclature used in the construction documents and shall be an active link to the first page of the section being referenced.

C. Operation and Maintenance Instructions shall include:

1. Title Page: Include title page with project title, Architect, Engineer, Contractor, all subcontractors, and major equipment suppliers, with addresses, telephone numbers, website addresses, email addresses and point of contacts. Website URLs and email addresses shall be active links in the electronic submittal.
2. Table of Contents: Include a table of contents describing specification section, systems, major equipment, and individual items.
3. Copies of all final <u>approved</u> shop drawings and submittals. Include Architect's/Engineer's shop drawing review comments. Insert the individual shop drawing directly after the Operation and Maintenance information for the item(s) in the review form.
4. Copy of final approved test and balance reports.
5. Copies of all factory inspections and/or equipment startup reports.
6. Copies of warranties.
7. Schematic wiring diagrams of the equipment that have been updated for field conditions. Field wiring shall have label numbers to match drawings.
8. Dimensional drawings of equipment.
9. Capacities and utility consumption of equipment.
10. Detailed parts lists with lists of suppliers.
11. Operating procedures for each system.
12. Maintenance schedule and procedures. Include a chart listing maintenance requirements and frequency.
13. Repair procedures for major components.

14. List of lubricants in all equipment and recommended frequency of lubrication.
15. Instruction books, cards, and manuals furnished with the equipment.

3.6 INSTRUCTING THE OWNER'S REPRESENTATIVE

A. Adequately instruct the Owner's designated representative or representatives in the maintenance, care, and operation of the complete systems installed under this contract.

B. Provide verbal and written instructions to the Owner's representative or representatives by FACTORY PERSONNEL in the care, maintenance, and operation of the equipment and systems.

C. The Owner has the option to make a video recording of all instructions. Coordinate schedule of instructions to facilitate this recording.

D. The Architect/Engineer shall be notified of the time and place for the verbal instructions to be given to the Owner's representative so that their representative can be present if desirable.

E. Refer to the individual specification sections for minimum hours of instruction time for each system.

F. Operating Instructions:

1. The Contractor is responsible for all instructions to the Owner and/or Owner's operating staff on the Communications Systems.
2. If the Contractor does not have Engineers and/or Technicians on staff who can adequately provide the required instructions on system operation, performance, troubleshooting, care and maintenance, they shall include in the bid an adequate amount to reimburse the Owner for the Architect/Engineer to perform these services.

3.7 SYSTEM STARTING AND ADJUSTING

A. The Communications Systems included in the construction documents are to be complete and operating systems. The Architect/Engineer will make periodic job site observations during the construction period. The system start-up, testing, configuration, and satisfactory system performance is the responsibility of the Contractor. This shall include all calibration and adjustments of electrical equipment controls, equipment settings, software configuration, troubleshooting and verification of software, and final adjustments that may be required.

B. All operating conditions and control sequences shall be simulated and tested during the start-up period.

C. The Contractor, subcontractors, and equipment suppliers are expected to have skilled technicians to ensure that the system performs as designed. If the Architect/Engineer is requested to visit the job site for the purpose of trouble shooting, assisting in the satisfactory start-up, obtaining satisfactory equipment operation, resolving installation and/or workmanship problems, equipment substitution issues or unsatisfactory system performance, including call backs during the warranty period through no fault of the design; the Contractor shall reimburse the Owner on a time and material basis for services rendered at the Architect/Engineer's standard hourly rates in effect at the time the services are requested. The Contractor shall be responsible for making payment to the Owner for services required that are product, installation or workmanship related. Payment is due within 30 days after services are rendered.

3.8 RECORD DOCUMENTS

A. Refer to the Division 1 Section: PROJECT CLOSEOUT for requirements. The following paragraphs supplement the requirements of Division 1.

B. Mark specifications to indicate approved substitutions, change orders, and actual equipment and materials used.

C. This Contractor shall maintain at the job site, a separate and complete set of technology drawings which shall be clearly and permanently marked and noted in complete detail any changes made to the location and arrangement of equipment or made to the Technology Systems and wiring as a result of building construction conditions or as a result of instructions from the Architect or Engineer. <u>All Change Orders, RFI responses, Clarifications and other supplemental instructions shall be marked on the documents</u>. Record documents that merely reference the existence of the above items are not acceptable. Should This Contractor fail to complete Record Documents as required by this contract, This Contractor shall reimburse Architect/Engineer for all costs to develop record documents that comply with this requirement. Reimbursement shall be made at the Architect/Engineer's hourly rates in effect at the time of work.

D. Record actual routing of all conduits sized 2" or larger.

E. The above record of changes shall be made available for the Architect and Engineer's examination during any regular work time.

F. Upon completion of the job, and before final payment is made, This Contractor shall give the marked-up drawings to the Architect/Engineer.

3.9 ADJUST AND CLEAN

A. Contractor shall thoroughly clean all equipment and systems prior to the Owner's final acceptance of the project.

B. Contractor shall clean all foreign paint, grease, oil, dirt, labels, stickers, and other foreign material from equipment.

C. Contractor shall remove all rubbish, debris, etc., accumulated during the Contractor's operations from the premises.

STATEMENT INDICATING READINESS FOR FINAL JOBSITE OBSERVATION

To assist the contractor in a timely close-out of the project, it is crucial that the final jobsite observation is not conducted prior to the project being ready. The contractor is required to review the completion status of the project at the time the observation is scheduled. This review, and the subsequent submittal of this form to the Architect/Engineer, shall indicate the contractor's agreement that the area of the project being requested for final observation is ready as defined below. The following list represents the degree of completeness required prior to requesting a final observation:

1. All cabling pathways (cable tray, ladder rack, conduit sleeves, etc.) are installed.
2. All mechanical firestop products are installed and all other penetrations have been sealed.
7. All telecommunications related grounding is complete.
10. All CCTV cameras, mounts, cabling and all headend equipment are installed, programmed and operational.
11. All access control system equipment, including card readers, conduits, cabling, electronic locks, controllers and all headend equipment, is installed, programmed and operational.

Prime Contractor: __________________________ By: ______________________________

Requested Observation Date _________________ Today's Date: ______________________

Contractor shall sign this readiness statement and transmit to Architect/Engineer at least 10 days prior to the requested date of observation.

It is understood that if the Architect/Engineer finds that the project is not complete as defined above and that the final jobsite observation cannot be completed on the requested date, the Architect/Engineer will return to the site at a later date. All additional visits to the site for the purposes of completing the final observation will be billed T&M to the Contractor at our standard hourly rates, including travel expenses or the contractor's retainage may be deducted for the same amount.

END OF SECTION 27 05 00

SECTION 27 05 05 - TECHNOLOGY DEMOLITION FOR REMODELING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Technology demolition.

1.2 RELATED WORK

A. Section 27 05 00 - Basic Communications Systems Requirements.

1.3 REFERENCES

A. NFPA 70 - National Electrical Code.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. Materials and equipment for terminating, patching and cross connecting of existing telecommunications and security systems shall be as specified in individual Sections.

PART 3 - EXECUTION

3.1 EXAMINATION

A. THE DRAWINGS ARE INTENDED TO INDICATE THE SCOPE OF WORK REQUIRED AND DO NOT INDICATE EVERY OUTLET, BOX, CONDUIT, OR CABLE THAT MUST BE REMOVED.

B. THE CONTRACTOR SHALL VISIT THE SITE PRIOR TO SUBMITTING A BID AND VERIFY EXISTING CONDITIONS AND SCOPE OF WORK.

C. Where walls, ceilings, structures, etc., are indicated as being renovated on general drawings, the Contractor shall be responsible for the removal of all technology equipment including but not limited to: copper, fiber and coaxial cable, faceplates and jacks, raceways, racking and equipment mounted to the racking, etc., from the renovated area.

D. Where ceilings, walls, structures, etc., are temporarily removed and replaced by others, this Contractor shall be responsible for the removal, storage, and replacement of equipment, devices, fixtures, raceways, wiring, systems, etc.

E. Verify that abandoned wiring and equipment serve only abandoned equipment or facilities. Extend conduit and wire to facilities and equipment that will remain in operation following demolition. Extension of conduit and wire to equipment shall be compatible with the surrounding area.

F. Coordinate scope of work with all other Contractors and the Owner at the project site. Schedule removal of equipment and technology service to avoid conflicts.

3.2 PREPARATION

A. Not all services within the building will be inactive or abandoned. Verify abandonment status with the building owner, General Contractor and Architect/Engineer prior to demolition.

B. Prior to commencing with demolition, a proposed implementation narrative with schedule shall be submitted to the Architect/Engineer for approval.

C. The contractor shall provide proof that only qualified personnel with extensive telecommunications experience will perform the demolition. No laborers will be allowed in the cable removal process.

D. The contractor shall coordinate with owner to verify all cabling, patch cords and cross connects have been removed from active equipment that is to remain during the duration of the renovation.

E. Provide temporary wiring and connections to maintain existing systems in service during construction. When work must be performed on active equipment, use technicians experienced in such operations. Assume all equipment and systems must remain operational unless specifically noted otherwise on drawings.

3.3 DEMOLITION AND EXTENSION OF EXISTING TECHNOLOGY WORK

A. Demolish and extend existing technology work under provisions of Division 1 of Architectural Specifications and this Section.

B. Some cabling within the ceiling space may serve other building tenants; care shall be exercised to prevent service interrupts.

C. Remove, relocate, and extend existing installations to accommodate new construction.

D. Remove abandoned low voltage cabling and raceway to source of cabling according to the NEC. Refer to the NEC for definition of Abandoned Communications Cabling.

E. Remove exposed abandoned raceway, including abandoned raceway above accessible ceiling finishes. Cut raceway flush with walls and floors, and patch surfaces. Remove all associated clamps, hangers, supports, etc. associated with raceway removal.

F. Disconnect abandoned outlets and remove devices. Remove abandoned outlets if conduit servicing them is removed. Patch openings created from removal of devices to match surrounding finishes.

G. Disconnect and remove abandoned patch panels, blocks and other distribution equipment.

H. Repair adjacent construction and finishes damaged during demolition and extension work. Patch openings to match existing surrounding finishes.

I. Maintain access to existing technology installations that remain active. Modify installation or provide access panels as appropriate.

J. Extend existing installations using materials and methods compatible with existing technology installations, or as specified.

K. Regulatory Requirements: Comply with governing EPA notification regulations before beginning demolition. Comply with hauling and disposal regulations of authorities having jurisdiction.

L. This Contractor is responsible for <u>all</u> costs incurred in repair, relocations, or replacement of any cables, conduits, or other services if damaged without proper investigation.

3.4 CLEANING AND REPAIR

A. Clean and repair existing materials and equipment that remain or are to be reused.

B. Patch panels, blocks and other connectivity equipment: Clean exposed surfaces and check tightness of connections. Re-terminate any loose connections; the contractor shall notify the Architect/Engineer of any permanently damaged or unusable equipment.

C. TECHNOLOGY ITEMS (E.G., PATCH PANELS, EQUIPMENT RACKS, JACKS, FACEPLATES, BLOCKS, CABLING, ETC.) REMOVED AND NOT RELOCATED REMAIN THE PROPERTY OF THE OWNER. CONTRACTOR SHALL PLACE ITEMS RETAINED BY THE OWNER IN A LOCATION COORDINATED WITH THE OWNER. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE DISPOSAL OF MATERIAL THE OWNER DOES NOT WANT.

3.5 INSTALLATION

A. Install relocated materials and equipment under the provisions of applicable Division 27 specifications.

END OF SECTION 27 05 05

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SECTION 27 05 26 - COMMUNICATIONS BONDING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Bonding Conductors

B. Bonding Connectors

C. Grounding Busbar (TMGB and TGB)

1.2 RELATED WORK

A. Section 26 05 33 - Conduit and Boxes

B. Section 26 05 36 - Cable Trays

C. Section 26 05 13 - Wire and Cable

D. Section 26 05 26 - Grounding and Bonding

E. Section 26 41 00 - Lightning Protection Systems

F. Section 27 05 00 - Basic Communications Systems Requirements

G. Section 27 11 00 - Communication Equipment Rooms

H. Section 27 05 28 - Interior Communication Pathways

1.3 QUALITY ASSURANCE

A. Refer to Section 27 05 00 for relevant standards.

B. Communications bonding system component, device, equipment, and material manufacturer(s) shall have a minimum of five (5) years documented experience in the manufacture of communications bonding products.

C. The entire installation shall comply with all applicable electrical codes, safety codes, and standards. All applicable components, devices, equipment, and material shall be listed by Underwriters' Laboratories, Inc.

1.4 REFERENCES

A. ANSI/IEEE 1100 - Recommended Practice for Power and Grounding Sensitive Electronic Equipment in Industrial and Commercial Power Systems

B. ANSI/TIA/EIA 568-C - Commercial Building Telecommunications Cabling Standard

C. ANSI/TIA/EIA 569-A - Commercial Building Standard for Telecommunications Pathways and Spaces

D. ANSI/TIA/EIA 606 - Administration Standard for the Telecommunications Infrastructure of Commercial Buildings

E. ANSI/TIA/EIA 758 - Customer Owned Outside Plant

F. ANSI-J-STD-607-A - Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications

G. IEEE 81 - IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System Part 1: Normal Measurements

H. NFPA 70 - National Electrical Code

I. NFPA 780 - Standard for the Installation of Lightning Protection Systems

J. UL 96 - Lightning Protection Components

K. UL 96A - Installation Requirements for Lightning Protection Systems

L. UL 467 - Grounding and Bonding Equipment

1.5 SUBMITTALS

A. Submit product data and shop drawings under provisions of Section 27 05 00 and Division 1.

B. Provide manufacturer's technical product specification sheet for each individual component type. Submitted data shall show the following:

1. Compliance with each requirement of these documents. The submittal shall acknowledge each requirement of this section, item-by-item, including construction, materials, ratings, and all other parameters identified in Part 2 - Products.
2. Manufacturer's installation instructions indicating application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of product.

C. Provide CAD-generated, project-specific system shop drawings as follows:

1. Provide a system block diagram indicating system configuration, system components, interconnection between components, and conductor routing. The diagram shall clearly indicate all wiring and connections required in the system. When multiple devices or pieces of equipment are required in the exact same configuration (e.g., multiple identical equipment racks or sections of ladder tray), the diagram may show one device and refer to the others as "typical" of the device shown. The diagram shall list room numbers where system equipment will be located.
2. Installation details for all system components.

D. Provide system checkout test procedure to be performed at acceptance.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to the site under the provisions of Section 27 05 00.

B. Store and protect products under the provisions of Section 27 05 00.

C. Contractor shall exercise care to prevent corrosion of any products prior to installation. Corroded products shall not be acceptable for use on this project.

1.7 SYSTEM DESCRIPTION

A. This section describes the requirements for the furnishing, installation, adjusting, and testing of a complete turnkey communications bonding system, including connection to the electrical ground grid.

B. Performance Statement: This specification section and the accompanying drawings are performance based, describing the minimum material quality, required features, operational requirements, and performance of the system. These documents do not convey every wire that must be installed, every equipment connection that must be made, or every feature and function that must be configured. Based on the equipment constraints described and the performance required of the system as presented in these documents, the Contractor is solely responsible for determining all components, devices, equipment, wiring, connections, and terminations required for a complete and operational system that provides the required performance.

C. This document describes the major components of the system. All additional hardware, subassemblies, supporting equipment, and other miscellaneous equipment required for complete, proper system installation and operation shall be provided by the Contractor.

D. Basic System Requirements:

1. A complete communications bonding infrastructure is required for this project. Refer to the drawings and the requirements of ANSI-J-STD-607-A and NFPA 70 for complete information.
2. The bonding system shall include, but not be limited to, the following major components:

a. Bonding Conductor for Telecommunications (BCT)
b. Telecommunications Main Grounding Busbar (TMGB)
c. Telecommunications Bonding Backbone (TBB)
d. Telecommunications Grounding Busbar(s) (TGB)
e. Rack mount Telecommunications Grounding Busbar(s)
f. Bonding Conductor(s) (BC)
g. Bonding Connectors
h. Bonding system labeling and administration as defined in Section 27 05 53.

1.8 PROJECT RECORD DOCUMENTS

A. Submit documents under the provisions of Section 27 05 00.

B. Provide final system block diagram showing any deviations from approved shop drawing submittal.

C. Provide floor plans that document the following:

1. Actual locations of system components, devices, and equipment.
2. Actual conductor routing.
3. Actual system component, device, equipment, and conductor labels.

D. Provide statement that system checkout test, as outlined in the approved shop drawing submittal, is complete and test results were satisfactory.

E. Complete all operation and maintenance manuals as described below.

1.9 OPERATION AND MAINTENANCE DATA

A. Submit under provisions of Section 27 05 00.

B. Submitted data shall include:

1. Approved shop drawings.

2. Descriptions of recommended system maintenance procedures, including:

   a. Inspection
   b. Periodic preventive maintenance
   c. Fault diagnosis
   d. Repair or replacement of defective components

PART 2 - PRODUCTS

2.1 BONDING CONDUCTORS

A. Bare Copper:

1. Annealed uncoated stranded conductor.
2. Minimum size 6 AWG.

B. Insulated Copper:

1. Annealed uncoated stranded conductor.
2. Insulation:

   a. PVC insulation with nylon outer jacket.
   b. Rated at 600 volts.
   c. Green.

3. Minimum size 6 AWG.

C. All bonding conductors shall be listed and recognized by a nationally recognized testing laboratory as being suitable for the intended purpose and for installation in the space in which they are installed.

D. Bonding Conductor Sizing:

1. All communications bonding system conductors shall be sized by length as follows:

Length Linear ft (m)	Size (AWG)
Less than 13 (4)	6
14 - 20 (4 - 6)	4
21 - 26 (6 - 8)	3
27 - 33 (8 - 10)	2
34 - 41 (10 - 13)	1
42 - 52 (13 - 16)	1/0
53 - 66 (16 - 20)	2/0
Greater than 66 (20)	3/0

2. The BCT shall be the same size as the TBB or larger.

2.2 BONDING CONNECTORS

A. Acceptable Types:

1. Two-hole compression lug
2. Exothermic weld
3. Irreversible compression

B. Connectors shall be provided in kit form and selected per manufacturer's written instructions.

C. Connectors shall comply with IEEE 837 and UL 467 and be listed for use for specific types, sizes, and combinations of conductors and connected items.

2.3 GROUNDING BUSBAR (TMGB AND TGB)

A. Features:

1. Wall-mount configuration.
2. Listed and recognized by a nationally recognized testing laboratory as being suitable for intended purpose.
3. Hole patterns compliant with BICSI recommendations and ANSI-J-STD-607-A standards.
4. Predrilled holes.
5. Integral insulators.
6. Stainless steel offset mounting brackets.

B. Specifications:

1. Material: Electrolytic tough pitch copper bar with tin plating.
2. Minimum Dimensions: 1/4" thick x 4" high x 12" long.

a. Increase dimensions and/or quantity furnished and installed as required to accommodate all terminations required by the project, plus 20% spare capacity.

3. Hole pattern shall include:

a. A minimum of 15 sets of 5/16" holes, 5/8" on center, to accommodate "A" spaced 2-hole compression lugs.
b. A minimum of three (3) sets of 7/16" holes, 1" on center, to accommodate "C" spaced 2-hole compression lugs.

2.4 RACK-MOUNT TELECOMMUNICATIONS GROUNDING BUSBAR

A. Features:

1. Listed and recognized by a nationally recognized testing laboratory as being suitable for intended purpose.
2. Predrilled holes.
3. Mounts in a standard 19" equipment rack.

B. Specifications:

1. Material: Electrolytic tough pitch copper bar with tin plating.
2. Minimum Dimensions: 3/16" thick x 3/4" high x 19" long.

a. Increase dimensions and/or quantity furnished and installed as required to accommodate all terminations required by the project, plus 20% spare capacity.

3. Hole pattern shall include:

a. A minimum of eight (8) 6-32 tapped lug mounting holes on 1" centers.
b. A minimum of two (2) pairs of 5/16" diameter holes spaced 3/4" apart.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General Bonding Requirements:

1. The communications bonding system shall be a complete system. Contractor shall furnish and install all necessary miscellaneous components, devices, equipment, material, and hardware, including, but not limited to, lock washers, paint-piercing washers, hex nuts, compression lugs, insulators, mounting screws, lugs, etc., to provide a complete system.
2. A licensed electrician shall perform all bonding.
3. Comply with the manufacturer's instructions and recommendations for installation of all products.

B. Main Cross Connect and Service Entrance Room Bonding Requirements:

1. Locate the TMGB in the service entrance room unless otherwise noted on the drawings.
2. The location of the TMGB shall be the shortest practical distance from the telecommunications primary lightning protection devices.
3. Bond the telecommunications primary protectors to the TMGB. Maintain a minimum 1 foot separation of the bonding conductor from all DC power cables, switchboard cable, and high frequency cable.

C. Telecommunications Main Ground Bar (TMGB) Requirements:

1. Install TMGB such that it is insulated from its support with a minimum 2" standoff.
2. Bond the TMGB to the electrical service ground via the BCT.

   a. A minimum of 1 foot separation shall be maintained between the BCT and any DC power cables, switchboard cable, or high frequency cables.

3. TMGB shall be bonded to all electrical panels located in the same room or space as the TMGB or in an immediately adjacent space within 20 linear feet of the TMGB. TMGB shall be bonded to all electrical panels providing electrical power to communications equipment located in the same room or space as the TMGB.
4. TMGB shall be bonded to accessible metallic building structure located within the same room or space as the TMGB.
5. All metallic continuous cable pathways, including, but not limited to, cable trays, basket trays, ladder racks, raceways, conduits, conduit sleeves, and fire-rated cable pathway devices, located within the same room or space as the TMGB, shall be bonded to the TMGB.
6. All metallic communications equipment, including, but not limited to, cable pair protectors, surge suppressors, cross-connect frames, patch panels, equipment cabinets, etc., located within the same room or space as the TMGB, shall be bonded to the TMGB.

D. Telecommunications Ground Bar (TGB) Requirements:

1. Provide a TGB in each telecommunications equipment room.
2. Install TGB such that it is insulated from its support with a minimum 2" standoff.
3. Bond each TGB to the TMGB via the TBB.

   a. A minimum of 1 foot separation shall be maintained between the TBB and any DC power cables, switchboard cable, or high frequency cables.
   b. The TBB may be routed from TGB to TGB or as a radial feed to each TGB as the layout requires.

4. When there are multiple telecommunications equipment rooms on <u>each</u> floor in buildings containing more than five stories, the TGBs on the same floor shall be bonded together horizontally using a grounding equalizer (GE) on the first, last, and every third intermediate floor. GE conductors shall be the same size as the TBB.

5. If more than one (1) TGB is provided within the same room or space, they shall all be bonded together via a BC the same size as the TBB.
6. TGBs shall be bonded to accessible metallic building structure located within the same room or space as the TGBs.
7. TGBs shall be bonded to all electrical panels located in the same room or space as the TGB or in an immediately adjacent space within 20 linear feet of the TGB. TGBs shall be bonded to all electrical panels providing electrical power to communications equipment located in the same room or space as the TGB.
8. All metallic continuous cable pathways, including, but not limited to, cable trays, basket trays, ladder racks, raceways, conduits, conduit sleeves, and fire-rated cable pathway devices, located within the same room or space as the TGB, shall be bonded to the TGB.
9. All metallic communications equipment, including, but not limited to, cable pair protectors, surge suppressors, cross-connect frames, patch panels, equipment cabinets, etc., located within the same room or space as the TGB, shall be bonded to the TGB.

E. Rack-mount Telecommunications Ground Bar Requirements (RTGB):

1. Provide a rack-mount telecommunications ground bar in each equipment rack and equipment rack enclosure.
2. Install RTGB such that it is electrically bonded to the rack. Where necessary, remove paint and/or use paint-piercing washers to provide proper electrical bond between RTGB and equipment rack.
3. Bond each RTGB to the TGB via a BC.
4. If more than one (1) RTGB is provided within the same room or space, they shall all be bonded together via a BC.
5. All contractor-furnished and/or contractor-installed metallic communications equipment, including, but not limited to patch panels, fiber optic distribution enclosures, splice enclosures, active electronics, uninterruptible power supplies, etc., mounted within the same equipment rack as the RTGB, shall be bonded to the RTGB. Where necessary, remove paint and/or use paint-piercing washers to provide proper electrical bond between equipment rack and installed metallic communications equipment. Active electronics and uninterruptible power supplies shall be bonded to the RTGB via a dedicated BC for each device.

F. Metallic Interior Communication Pathway Bonding Requirements:

1. All metallic interior continuous communication cable pathways, including, but not limited to, conduit, conduit sleeves, fire-rated cable pathway devices, cable tray, basket tray, and ladder rack, shall be bonded to the communications bonding system.

G. Bonding Conductor Requirements:

1. Bonding conductors shall be green or marked with a distinctive green color.
2. Bonding conductors shall be routed parallel and perpendicular to building structure along shortest and straightest paths possible. Number of bends and changes in direction should be minimized. Install and secure conductors in a manner that protects the conductors from impact and from physical or mechanical strain or damage.
3. Bonding conductors shall not be installed in metallic conduit.
4. All conductors, including, but not limited, to the BCT, TBB, GE(s), and BC(s), shall be installed splice-free. If the Contractor believes that site conditions do not allow a splice-free installation, the Contractor may request permission from the Architect/Engineer to splice a specific communications bonding system conductor.

   a. Where documented permission to splice a conductor is granted:

      1) The number of splices shall be limited to as few as possible.
      2) Splices shall be made using exothermic welding or irreversible compression-type connections only. Splice hardware shall be listed for grounding and bonding. Solder is not an acceptable means of splicing conductors.
      3) Splices shall be made in telecommunications spaces in accessible locations to facilitate future inspection and maintenance.
      4) Splices shall be adequately supported and protected from impact and from physical or mechanical strain or damage.

5. All bonding conductors shall be labeled in accordance with the requirements of Section 27 05 53. In addition to the requirements of Section 27 05 53:

   a. Labels shall be nonmetallic.
   b. Labels shall be printer-generated.
   c. Labels shall be located on conductors as close as is practical to their point of termination in a readable position.
   d. Additionally, conductors shall be labeled as follows:

      1) "IF THIS CONNECTOR OR CABLE IS LOOSE OR MUST BE REMOVED, PLEASE CALL THE BUILDING TELECOMMUNICATIONS MANAGER."

6. Interior water piping is not acceptable for use as a communications bonding system bonding conductor.
7. Metallic cable shields are not acceptable for use as communications bonding system bonding conductors.

H. Bonding Connection Requirements:

1. Make all connections in accessible locations to facilitate future inspection and maintenance.
2. Communications bonding system connections shall be made using exothermic welding, two-hole compression lugs, or other irreversible compression-type connections. <u>The use of 1-hole lugs is prohibited</u>, except for connections to a rack-mount telecommunications ground bar. Connection hardware shall be listed for grounding and bonding. Sheet metal screws shall not be used to make communications bonding system connections.
3. Thoroughly clean conductors before installing lugs and connectors.
4. Install and tighten all connectors in accordance with manufacturer's instructions, using the appropriate purpose-designed tool(s) recommended by the manufacturer for that purpose. Exercise care not to tighten connectors beyond manufacturer's recommendations.
5. Where necessary, remove paint and/or use paint-piercing washers to provide proper electrical bond at all connections.
6. All bonding connections shall be coated in anti-oxidant joint compound that is purpose-designed and purpose-manufactured for that use. Anti-oxidant joint compound shall be applied in accordance with manufacturer's recommendations and instructions.
7. All installed connectors on conductors installed in damp locations shall be sealed with dielectric grease and then covered with heat shrink tubing to protect against moisture ingress. Applied heat shrink tubing shall overlap conductor's outer jacket a minimum of four (4) inches past connector and be installed in accordance with manufacturer's recommendations and instructions.

3.2 FIELD QUALITY CONTROL

A. Field inspection and testing shall be performed under provisions of Section 27 05 00.

B. Where these specifications require a product or assembly without the use of a brand or trade name, provide a product from a reputable manufacturer that meets the requirements of the specifications.

C. Periodic observations will be performed during construction to verify compliance with the requirements of the specifications. These services do not relieve the Contractor of responsibility for compliance with the contract documents.

3.3 ADJUSTING

A. Adjust work under provisions of Section 27 05 00.

B. Contractor shall make any and all adjustments to the communications bonding system necessary to ensure that the installed system meets all requirements listed herein. Modifications necessary to comply with listed requirements or to provide specified performance shall be completed by the Contractor at no additional cost to the Owner.

3.4 TESTING

A. Test installed system under provisions of Section 27 17 10.

B. Measure and document resistance to ground at TMGB, each TGB, each RTGB, and each electrical distribution panel bonded to the TMGB or a TGB.

1. Measurements shall be made not less than two full days after the last trace of precipitation, and without the soil being moistened by any means other than natural drainage or seepage, and without chemical treatment or other artificial means of reducing natural ground resistance. Perform tests by the fall-of-potential method according to IEEE 81.
2. Measured resistance to ground at TMGB, each TGB, and each RTGB must not exceed 5 ohms.
3. Under no circumstances shall any point in the communications bonding system have a lower resistance to ground than that of nearby electrical distribution system components that it is bonded to.

C. Include measurement documentation in test data submitted at completion of project under provisions of Section 27 17 10.

3.5 SYSTEM TRAINING

A. All labor and materials required for on-site system training shall be provided. Training shall be conducted at the project site using the project equipment.

1. Provide two week's advanced notice of training to the Owner and Architect/Engineer.
2. The Architect/Engineer shall be presented with the option to attend the training.
3. Provide a training outline agenda describing the subject matter and the recommended audience for each topic.

B. At a minimum, the following training shall be conducted:

1. A course detailing the system functions and operations that a technical user will encounter. Provide training on all aspects of using the system, including making new bonding connections to the TMGB, TGB, or RTGB. Provide training on all recommended inspection, maintenance, and repair procedures for the system.

C. Minimum on-site training times shall be:

1. Technical user: Four hours.

END OF SECTION 27 05 26

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SECTION 27 05 28 - INTERIOR COMMUNICATION PATHWAYS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. The work covered under this section consists of the furnishing of all necessary labor, supervision, materials, equipment, tests and services to install complete wire mesh support systems, conduits, sleeves, innerduct, etc. for an interior cabling plant as shown on the drawings.

B. Wire mesh support systems are defined to include, but are not limited to straight sections of continuous wire mesh, field formed horizontal and vertical bends, tees, drop outs, supports and accessories.

1.2 RELATED WORK

A. Section 26 05 33 - Conduit and Boxes

B. Section 27 05 00 - Basic Communications Systems Requirements

C. Section 27 05 26 - Communications Bonding

1.3 QUALITY ASSURANCE

A. Refer to Section 27 05 00 for requirements.

1.4 REFERENCES

A. ANSI/NFPA 70 - National Electrical Code

B. NEMA VE 2-2000 - Cable Tray Installation Guidelines

1.5 SUBMITTALS

A. Under the provisions of Section 27 05 00 and Division 1, prior to the start of work the Contractor shall submit:

1. Manufacturer's data covering <u>all</u> products proposed, including construction, materials, ratings and all other parameters identified in Part 2 - Products, below.
2. Manufacturer's installation instructions.

B. Coordination Drawings:

1. Include cable tray and conduit sleeve layout in composite electronic coordination files. Refer to Section 27 05 00 for coordination drawing requirements.

1.6 DRAWINGS

A. The drawings, which constitute a part of these specifications, indicate the general route of the wire mesh support systems, conduit, sleeves, etc. Data presented on these drawings is as accurate as preliminary surveys and planning can determine until final equipment selection is made. Accuracy is not guaranteed and field verification of all dimensions, routing, etc., is required.

PART 2 - PRODUCTS

2.1 CONDUIT

A. Refer to Section 26 05 33 for conduit requirements for this project.

2.2 WIRE MESH CABLE TRAY - OVERHEAD

A. General: Provide wire mesh of types and sizes indicated on drawings; with connector assemblies, clamp assemblies, connector plates, splice plates and splice bars. Provide drop-out fittings where cable tray is installed over equipment racks. Two drop-out fittings shall be installed over each rack so that a controlled radius is maintained into each side of every equipment rack that cable tray passes over. Construct units with rounded edges and smooth surfaces; in compliance with applicable standards; and with the following additional construction features.

B. Wire mesh shall be made of high strength steel wires and formed into a standard 2 inch by 4-inch wire mesh pattern with intersecting wires welded together. All wire ends along wire mesh sides (flanges) shall be rounded during manufacturing for safety of cables and installers.

C. Materials and Finishes: Material and finish specifications for each wire mesh type are as follows:

1. Electro-Galvanized Zinc: Straight sections shall be made from steel meeting the minimum mechanical properties of ASTM A510 and shall be electro-plated zinc in accordance with ASTM B633 SC2. .
2. Accessories:

    a. Pre-Galvanized Zinc: Wall brackets and other pre-galvanized accessories shall be coated with zinc in accordance with ASTM A653.
    b. Electro-Galvanized Zinc: Support accessories and miscellaneous hardware shall be coated in accordance with ASTM B633 SC3. All threaded components shall be coated in accordance with ASTM B633 SC1.

D. Type of Overhead Wire Mesh Support System:

1. All straight section longitudinal wires shall be straight (with no bends).
2. Wire mesh supports shall be trapeze hangers or wall brackets. Center hung supports will <u>not</u> be allowed.
3. Trapeze hangers are to be supported by 1/4 inch or 3/8-inch diameter rods.
4. Provide manufacturer approved grounding clips as necessary for continuous grounding of tray.
5. Basis of Design
    a. nVent Caddy WBTray "Shaped" WBT#x# S Series
6. Additional acceptable manufacturers:
    a. Cooper B-Line "Flextray"
    b. Cablofil, Inc,
    c. Wiremold "Fieldmate"

2.3 CABLE HANGERS AND SUPPORTS

A. Provide a non-continuous cable support system suitable for use with open cable.

B. Cable Hooks:

1. Construction: Flat bottom design with a minimum cable bearing surface of 1-5/8". Hooks shall have 90-degree radius edges.
2. All cable hook mounting hardware shall be recessed to prevent damage to cable during installation. Installed cabling shall be secured using a cable latch retainer that shall be removable and reusable.
3. Finish: Pre-galvanized steel, ASTM A653 suitable for general duty use.

2.4 INNERDUCT - CORRUGATED

A. Fabricated from self-extinguishing high-impact polyvinyl chloride (PVC), orange in color.

B. Fittings and accessories fabricated from same material as conduit and usable with rigid nonmetallic conduit.

C. Solvent-cement type joints as recommended by manufacturer.

D. Inside diameter not less than that of rigid steel conduit.

E. Dielectric strength a minimum of 400 volts per mil.

F. Corrugated wall construction.

G. Pull rope pre-installed by manufacturer.

H. Innerduct installed within buildings (not including riser paths) or utility tunnels shall meet all the above General requirements plus:

1. Be fabricated of flame-retardant materials (plenum rated) suitable for installation in such environments.
2. Meet or exceed all requirements for flame resistant duct as required by Bellcore TR-NWT-000356 (Section 4.33).

I. Innerduct installed within building riser shafts shall meet all the above general requirements plus:

1. Be fabricated of flame-retardant materials suitable for installation in such environment.

J. Meet or exceed all requirements for flame propagation as specified by test method UL-1666 and referenced by the National Electrical Code (NEC) Section 770-53 for listed optical fiber raceways being installed in vertical runs in a shaft between floors.

PART 3 - EXECUTION

3.1 INNER DUCT INSTALLATION REQUIREMENTS

A. Inner duct shall be riser or plenum rated as required by the installation environment. At minimum, inner duct should extend to the ladder rack above the termination enclosure at system endpoints. Where not installed in a continuous length, inner duct segments should be spliced using couplings designed for that purpose.

B. All exposed inner duct is to be labeled at 35-foot intervals with tags indicating ownership, the cable type (e.g., "Fiber Optic Cable") and the cables it contains (e.g., MA-CS or FS-CS).

C. Where exposed, fiber optic cable shall be installed in protective inner duct.

D. Contractor shall determine optimum size and quantity to satisfy the requirements of the installation and to ensure that the mechanical limitations, including minimum bend radius of the cable, are considered.

E. The inner duct should extend into the termination enclosure at system endpoints.

F. Where not installed in a continuous length, inner duct segments should be spliced using couplings designed for that purpose.

3.2 CABLE HOOK SUPPORT SYSTEM

A. In areas where cabling is not supported by cable tray, ladder rack, enclosed wireway or installed in conduit, such cabling shall be supported by an approved cable hook support system.

B. Refer to manufacturer's requirements for allowable fill capacity for selected cable hook. In no case shall a 40% fill capacity be exceeded.

C. Cable hooks shall be securely mounted per manufacturer's instructions. In no case shall the side-to-side travel of any cable hook exceed 6".

D. Cable hooks shall be selected based on the contractor's cable routing. Hooks shall be capable of supporting a minimum of 30 pounds with a safety factor of 3.

E. J-hook support spans shall be based on the smaller of the manufacturer's load ratings and code requirements. In no case shall horizontal spans exceed 5 feet and vertical spans exceed 4 feet.

F. The resting and supporting of cabling on structural members shall <u>not</u> meet the requirements for cabling support specified herein.

G. The use of tie-wraps or hook and loop type fasteners is specifically prohibited as a substitute for cable hooks specified herein.

3.3 CONDUIT AND CABLE ROUTING

A. Refer to Section 26 05 33 for additional requirements.

B. All conduits shall be reamed and shall be installed with a nylon bushing.

C. Maintain appropriate conduit bend radius at all times. For conduits with an internal diameter of less than 2", maintain a bend radius of at least 6 times the internal diameter. For conduits with an internal diameter 2" or greater, maintain a bend radius of at least 10 times the internal diameter.

D. No conduit or sleeve containing more than two (2) cables shall exceed 40% fill ratio, regardless of length.

E. Any conduit exceeding 90' in length or containing more than two (2) 90-degree bends shall contain a pull box sized per ANSI/TIA/EIA 569 requirements.

1. A separate pull box is required for each 90' (or greater) length section.
2. A separate pull box is required after any two (2) consecutive 90-degree bends.
3. Pull box shall be located in an area that maintains accessibility of box, including the ability to remove box lid without removal or relocation of any other materials.

F. Any conduit with bends totaling 90 degrees or more shall have the fill capacity derated by 15% for each 90 degrees of cumulative bend.

G. Cables installed in any conduits that do not meet the above requirements shall be replaced at the Contractor's expense, after the conduit condition has been remedied.

3.4 WIRE MESH TRAY INSTALLATION

A. The wire mesh cable tray system shall be only for telecommunications.

B. Install wire mesh as indicated; in accordance with recognized industry practices (NEMA VE-2 2000), to ensure that the cable tray equipment complies with requirements of NEC, and applicable portions of NFPA 70B and NECA's "Standards of Installation" pertaining to general electrical installation practices.

C. Cable tray sections shall be grounded in accordance with manufacturer's recommendations using manufacturer approved hardware. Painted sections shall have paint removed at each grounding attachment point.

D. Test wire mesh support systems to ensure electrical continuity of bonding and grounding connections, and to demonstrate compliance with specified maximum grounding resistance. Refer to NFPA 70B, Chapter 18, for testing and test methods.

E. Provide sufficient space encompassing wire mesh to permit access for installing and maintaining cables.

F. Tray shall be continuous from source to termination and shall not change elevation, direction or otherwise expose cables to travel without 2" x 4" mesh support.

G. Overhead Tray shall be field cut using only manufacturer approved cutting device and methods. Cutting device shall be an offset blade bolt cutter; standard bolt cutters are specifically not permitted.

H. Bends in overhead tray shall be accomplished by utilizing manufacturer's cutting guides.

I. All splices of tray shall be provided with splice washers, bars or springs as recommended by the manufacturer.

3.5 ATTACHMENT TO METAL DECKING

A. Where supports for cable trays and cable hook systems attach to metal roof decking, excluding concrete on metal decking, do not exceed 25 lbs. per hangar and a minimum spacing of 2'-0" on center. This 25-lb. load and 2'-0" spacing include adjacent electrical and mechanical items hanging from deck. If the hanger restrictions cannot be achieved, supplemental framing off steel framing will need to be added.

END OF SECTION 27 05 28

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SECTION 27 11 00 - COMMUNICATION EQUIPMENT ROOMS (CER)

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This section describes the products and execution requirements related to furnishing and installing equipment for communication equipment rooms.

1.2 RELATED WORK

A. Section 27 05 00 - Basic Communications Systems Requirements

B. Section 27 05 26 - Communications Bonding

C. Section 27 05 28 - Interior Communication Pathways

D. Section 27 15 00 - Horizontal Cabling Requirements

1.3 SUBMITTALS

A. Under the provisions of Section 27 05 00 and Division 1, prior to the start of work the Contractor shall submit:

1. Manufacturer's data covering <u>all</u> products including construction, materials, ratings and all other parameters identified in Part 2 - Products, below.

B. Coordination Drawings:

1. Include ladder racking, equipment racks, cable tray and conduit sleeve layout in composite electronic coordination files. Refer to Section 27 05 00 for coordination drawing requirements.

PART 2 - PRODUCTS

2.1 EQUIPMENT GROUNDING

A. Refer to specification section 27 05 26 for grounding requirements.

B. All equipment required to be grounded shall be provided with a grounding lug suitable for termination of the specified size electrode conductor.

2.2 EQUIPMENT RACKS AND CABINETS

A. Where identified on the drawings in Communication Equipment Rooms, equipment racks and/or equipment cabinets shall be furnished and installed by the Owner to house cable termination components (e.g., copper, optical fiber, coax) and network electronics.

2.3 PATCH PANELS

A. Where identified on the drawings in Communication Equipment Rooms, modular patch panels shall be furnished and installed by the Owner for termination of copper cable.

2.4 LADDER RACK

A. Provide complete ladder rack system including metallic ladder rack, splice connectors, fastening hardware and other miscellaneous materials as required for a complete installation per manufacturer's recommendations.

B. Tubing Style Ladder Rack:

1. Rolled steel siderail stringer, minimum 1.5" stringer height, 9" spaced welded rungs.
2. Steel shall meet the requirements of ASTM A1011 SS Grade 33.
3. Loading limits shall be 185 lbs/ft for 4 ft spans.

C. Ladder rack finish shall be flat black powder coat.

PART 3 - EXECUTION

3.1 EQUIPMENT RACKS

A. Equipment racks shall be furnished and installed by the Owner.

B. Each rack shall be grounded to the Telecommunications Ground Bar (GND) using a #6 AWG (or larger) insulated stranded copper conductor (GREEN jacket) directly or via an adjacent grounded equipment rack. Refer to grounding requirements below.

3.2 LADDER RACK

A. Provide support for ladder rack on 4 ft centers.

B. Maintain a 1.5 safety factor on all load limits specified herein.

C. Ladder rack support shall be by 5/8" diameter threaded rod when ceiling mounted. Ladder rack requiring wall mounting shall utilize accessories supplied by the ladder rack manufacturer specifically for the purpose of wall mounting ladder rack.

3.3 D-RINGS

A. Provide D-rings for cable routing and management in all areas where open cabling is routed along the wall in an Equipment Room.

B. Locate D-rings on 24" centers vertically and horizontally.

C. Securely attach D-rings to the wall as required by the manufacturer.

3.4 GROUNDING

A. Provide a complete grounding system in accordance with the requirements of Section 27 05 26.

3.5 CONDUITS AND CABLE ROUTING

A. Refer to Section 26 05 33 for additional requirements.

B. Where conduits enter a telecommunications room, conduits shall be terminated on the wall where shown on the contract documents. Conduits entering the room from the floor shall extend 3" above the floor slab.

C. Where cabling rises vertically in a telecommunications rooms, provide vertical cable management to support the cabling from floor to ceiling level.

D. All conduits shall be reamed and shall be installed with a nylon bushing.

E. Maintain appropriate conduit bend radius at all times. For conduits with an internal diameter of 2" or less, maintain a bend radius of at least 6 times the internal diameter. For conduits with an internal diameter greater than 2", maintain a bend radius of at least 10 times the internal diameter.

END OF SECTION 27 11 00

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SECTION 27 13 00 - BACKBONE CABLING REQUIREMENTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This section describes the products and execution requirements relating to furnishing and installing backbone communications cabling and termination components and related subsystems as part of a cabling plant. The cabling plant consists of both optical fiber and/or copper cabling.

1.2 RELATED WORK

A. Section 27 05 00 - Basic Technology Systems Requirements.

B. Section 27 15 00 - Horizontal Cabling Requirements.

C. Section 27 17 20 - Structured Cabling System Warranty.

1.3 QUALITY ASSURANCE

A. Refer to Section 27 05 00 for relevant standards.

1.4 SUBMITTALS

A. Under the provisions of Section 27 05 00 and Division 1, prior to the start of work the Contractor shall submit:

1. Manufacturer's data covering <u>all</u> products proposed, including construction, materials, ratings and all other parameters identified in Part 2 - Products, below.

PART 2 - PRODUCTS

2.1 GENERAL

A. The basis of design is listed herein. Refer to Section 27 17 20 for additional acceptable manufacturers.

PART 3 - EXECUTION

3.1 CABLE INSTALLATION REQUIREMENTS

A. Cable slack shall be provided in each backbone fiber optic cable. This slack is exclusive of the length of fiber that is required to accommodate termination requirements and is intended to provide for cable repair and/or equipment relocation. The cable slack shall be stored in a fashion as to protect it from damage and be secured in the termination enclosure or a separate enclosure designed for this purpose. Multiple cables may share a common enclosure.

B. A minimum of 5 meters (approximately 15 feet) of slack cable (each cable if applicable) shall be coiled and secured at both ends located in the entrance room, Telecommunications Room or main equipment room, for backbone and intra-building cable.

C. Where exposed, all backbone fiber optic cable shall be installed in protective inner duct. This includes areas where the cable is routed in cable tray and where making a transition between paths (e.g., between conduit and cable tray or into equipment racks). The inner duct should extend into the termination and/or storage enclosure(s) at system endpoints.

3.2 CROSS-CONNECTS

A. The Owner will be responsible for all cross-connects between the data backbone cabling and network electronics and between the data network electronics and horizontal cabling.

B. The Owner shall be responsible for the cross-connect wiring between the horizontal and backbone voice cabling.

C. This Contractor shall not be responsible for cross-connects between the cabling terminations at the Entrance Room and the telephone utility network point-of-presence. It shall be the responsibility of the Contractor, to work with the Owner and provide the necessary assistance to allow Owner and/or telephone company personnel to make the necessary connections to establish service on the new cable system. These activities include, but are not limited to cross-connect documentation, general wiring overview and cable pair identification.

END OF SECTION 27 13 00

SECTION 27 15 00 - HORIZONTAL CABLING REQUIREMENTS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. This section describes the products and execution requirements relating to furnishing and installing horizontal communications cabling and termination components and related subsystems as part of a cabling plant. The cabling plant consists of copper cabling.

1.2 RELATED WORK

A. Section 27 05 00 - Basic Communications Systems Requirements

1.3 QUALITY ASSURANCE

A. Refer to Section 27 05 00 for relevant standards and plenum or non-plenum cable requirements.

B. The channel shall be required to meet the performance requirements indicated herein. The manufacturer shall warranty the performance of their system to the required performance (and not just to the Standard, should the required performance exceed the Standard).

C. Specific components of the channel shall be required, at a minimum, to meet the Standard component requirements for that particular component.

D. The installing contractor must be certified by the manufacturer of the structured cabling system.

PART 2 - PRODUCTS

2.1 HORIZONTAL CABLE

A. CAT 6A Cable:
   1. All horizontal cable requirement will be furnished and installed by the Owner.

2.2 FACEPLATES/JACKS

A. Cat 6A Jacks:

   1. All horizontal cable faceplates and jacks will be furnished and installed by the Owner.

PART 3 - EXECUTION

3.1 CABLE INSTALLATION REQUIREMENTS

A. Horizontal Cabling will be furnished and installed by the Owner.

END OF SECTION 27 15 00

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SECTION 28 31 00 - FIRE ALARM AND DETECTION SYSTEMS

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Fire alarm and detection systems.

B. One-way emergency communications system with voice notification within-building, coverage.

1.2 RELATED WORK

A. Section 26 05 53 - Electrical Identification: Refer to electrical identification for color and identification labeling requirements.

1.3 QUALITY ASSURANCE

A. Manufacturer: Company specializing in smoke detection and fire alarm systems with ten years' experience.

B. Installer: A factory-authorized Electrical or Security Contractor licensed with the State and local jurisdiction with five years' experience in the design, installation, and maintenance of fire alarm systems by that manufacturer.

C. Qualifications: The person managing/overseeing the preparation of shop drawings and the system installation/programming/testing shall be trained and certified by the system manufacturer and shall be Fire Alarm Certified by NICET, minimum Level 3. This person's name and certification number shall appear on the start-up and testing reports.

1.4 REFERENCES

A. ASME A17.1 - Safety Code for Elevators and Escalators

B. NFPA 20 - Standard for Centrifugal Fire Pumps

C. NFPA 70 - National Electrical Code (NEC)

D. NFPA 72 - National Fire Alarm and Signaling Code

E. NFPA 101 - Life Safety Code

F. UL 2017 - General Purpose Signaling Devices and Systems

G. UL 217 / 268 - Standard for Smoke Alarms / Smoke Detectors for Fire Alarm Systems

H. UL 2572 - Control and Communication Units for Mass Notification Systems

I. 2012 International Fire Code

1.5 SUBMITTALS

A. Submit shop drawings and product data under provisions of Section 26 05 00 and as noted below.

1. Failure to comply with all the following and all the provisions in 26 05 00 will result in the shop drawing submittal being rejected without review.
2. Failure to submit the fire alarm without all requirements fulfilled in a single comprehensive submittal will be grounds to require a complete resubmittal.

B. Provide product catalog data sheets as shop drawings.

1. Provide a product catalog data sheet for each item shown on the Electrical Symbols List and for each piece of equipment that is not shown on the drawings, but required for the operation of the system.
2. Where a particular Electrical Symbols List item has one or more variations (such as those denoted by subscripts, etc.) a separate additional product catalog data sheet shall be provided for each variation that requires a different part number to be ordered. The corresponding Electrical Symbols List symbol shall be shown on the top of each sheet.
3. Where multiple items and options are shown on one data sheet, the part number and options of the item to be used shall be clearly denoted.

C. Submit CAD Floor Plans as Shop Drawings:

1. The complete layout of the entire system, device addresses, auxiliary equipment, and manufacturer's wiring requirements shall be shown.
2. Indicate the precise routing of notification appliance circuits under the provisions of circuit survivability. Refer to "Wiring" under Part 3 - Execution of this specification section for requirements.
3. A legend or key shall be provided to show which symbols shown on the submittal floor plans correspond with symbols shown on the Contract Documents.

D. About all fire alarm circuits, provide the following: manufacturer's wiring requirements (manufacturer, type, size, etc.) and voltage drop calculations.

E. Provide installation and maintenance manuals under provisions of Section 26 05 00.

F. Submit manufacturer's certificate that system meets or exceeds specified requirements.

G. Provide information on the system batteries as follows: total battery capacity, total capacity used by all devices on this project, total available future capacity.

H. Voice Alarm Communication System: Submit equipment rack or console layout, grounding schematic, amplifier power calculations, and wiring diagram.

I. Submit photocopy proof of NICET certification of the person overseeing the preparation of drawings and installation/testing.

J. When required to comply with local or state regulatory reviews, the fire alarm submittal shall have a NICET Certification of the state in which the project is completed. NOTE: The Architect/Engineer cannot stamp and seal submittal drawings not prepared under their supervision.

1.6 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Provide quantity equal to 2 percent (2%) of amount of each type installed, but no less than two (2) units of each type.

a. Smoke and heat detectors, manual pull stations, duct smoke detectors, monitor modules, control modules and relays.
b. Notification Appliances: Speakers, speaker strobes, and strobes.

2. Keys: The installing contractor shall collect all equipment spare keys provided with each lockable or resettable device/cabinet minimum of one (1) set each and shall turn over to the Owner upon completion.
3. All spare parts shall be housed in metal cabinet labeled "Fire Alarm Spare Parts."

1.7 DELIVERY, STORAGE, AND HANDLING

A. Deliver products to site under provisions of Section 26 05 00.

B. Store and protect products under provisions of Section 26 05 00.

1.8 REGULATORY REQUIREMENTS

A. System: UL or FM Global listed.

B. Conform to requirements of NFPA 101.

C. Conform to requirements of Americans with Disabilities Act (ADA).

D. Conform to UL 864 Fire Alarm, UL 1076 Security, UL2017 General Signaling, and UL 2572 Mass Notification Communications.

1.9 SYSTEM DESCRIPTION

A. Performance Statement: This specification section and the accompanying fire alarm specific design documents describe the minimum material quality, required features, and operational requirements of the system. These documents do not convey every wire that must be installed and every equipment connection that must be made. Based on the equipment described and the performance required of the system, as presented in these documents, the Vendor and the Contractor are solely responsible for determining all wiring, programming and miscellaneous equipment required for a complete and operational system.

B. This section of the specifications includes the furnishing, installation and connection of the microprocessor controlled, intelligent reporting, fire alarm equipment required to form a complete coordinated system that is ready for operation. It shall include, but is not limited to, alarm initiating devices, voice evacuation equipment, control panels, auxiliary control devices, annunciators, power supplies, and wiring as indicated on the drawings and specified herein.

C. Integrating the Existing Fire Alarm System: Provide all items, components, devices, hardware, software, programming, expansion components, conduit, wiring etc. needed to integrate fire alarm system with the new fire alarm system. This includes, but is not limited to, additional power supplies, initiating devices and circuits, signaling devices and circuits, monitoring devices and circuits, auxiliary control and related devices such as, door holders and their control, smoke damper control, fan shutdown, etc. The existing fire alarm system shall be integrated with the new fire alarm system such that the existing fire alarm system's functionality, integrity and annunciation shall be equivalent to pre-construction conditions, unless noted otherwise. The functionality and integrity shall be maintained during construction. The entire system shall be able to be completely reset from any single reset location point. The entire system shall be annunciated at any annunciation location.

D. Extending the Existing Simplex 4010 Fire Alarm System: The existing control panel shall remain and shall be operational throughout construction. The system shall only be disabled to make new connections and to modify the programming. A fire watch shall be provided for all areas affected during outages. All system outages must be scheduled with the Owner at least one week prior. Individual devices may be disabled as needed based on construction activities to reduce the potential for false alarms, but all devices must be operational when the Contractor is not physically on site. New initiating devices may be connected to the existing signaling line circuits where capacity is available. Provide additional signaling line circuits as needed based on existing and new device quantity, including replacement of existing panel components. Provide new notification circuits to serve the new devices, including all necessary power supplies, amplifiers, batteries, and 120-volt input circuits. All new devices shall be programmed to provide the same sequence of operation as the existing devices of the same type, unless noted otherwise.

E. Fire Alarm System: NFPA 72; Automatic and manual fire alarm system, non-coded, analog-addressable with automatic sensitivity control of certain detectors, multiplexed signal transmission.

F. Campus Ethernet IP Network: A complete fire alarm and mass notification Ethernet network shall be provided. The network shall be Class X, Resilient Ethernet Protocol (REP) 100BaseTX / 100 Mbps that shall be able to operate with any single break and self-restoring network communications. Each building shall contain an independent building fire alarm / voice communications system, with full command and control from the campus command center. In no case shall read only network annunciation be acceptable as the only networking function.

G. In-Building Network: A complete fire alarm system network shall be provided. Provide quantity of control panels as indicated on the drawings. The network shall be a Style 7 token ring, peer-to-peer network. The network shall be characterized by simultaneous or sequential transmission, or both, and reception of multiple signals on a signaling line circuit or communication channel. The distributed intelligent characteristic of the network shall provide for all nodes independently making pertinent system decisions with no need for a central controller. Each node shall be capable of independent operation should loss of network communications occur. In no case shall read-only network annunciation be acceptable as the only networking function.

H. Voice Communication: The facility shall have an emergency voice alarm communication system. The digitized recorded voice message shall notify occupants that a fire condition has been reported. Emergency manual voice override shall be provided.

I. System Supervision: Provide electrically supervised system, with supervised Signal Line Circuit (SLC) and Notification Appliance Circuit (NAC). Occurrence of single ground or open condition in initiating or signaling circuit places circuit in TROUBLE mode. Component or power supply failure places system in TROUBLE mode.

J. Alarm Reset: Key-accessible RESET function resets alarm system out of ALARM if alarm initiating circuits have cleared.

K. Lamp Test: Manual LAMP TEST function causes alarm indication at each zone at fire alarm control panel and at annunciator panels.

L. Drawings: Only device layouts and some equipment have been shown on the contract drawings. Wiring and additional equipment to make a complete and functioning system has not been shown, but shall be submitted on the shop drawings.

1.10 PROJECT RECORD DOCUMENTS

A. Submit documents under the provisions of Section 26 05 00.

B. Include location of end-of-line devices.

C. Provide a CAD drawing of each area of the building (minimum scale of 1/16" = 1'-0") showing each device on the project and its address. The devices shall be shown in their installed location and shall be labeled with the same nomenclature as is used in the fire alarm panel programming.

D. Submit test results of sound pressure level (dBA) and intelligibility (STI) with the rooms tested designated on the floor plan. Notification devices shall have the tap wattage designated.

1.11 OPERATION AND MAINTENANCE DATA

A. Submit data under provisions of Section 26 05 00.

B. Include operating instructions, and maintenance and repair procedures.

C. Include results of testing of all devices and functions.

D. Include manufacturer's representative's letter stating that system is operational.

E. Include the CAD floor plan drawings.

F. Include shop drawings as reviewed by the Architect/Engineer and the local Authority Having Jurisdiction.

1.12 WARRANTY

A. Provide one (1) year warranty on all materials and labor from Date of Substantial Completion.

B. Warranty requirements shall include furnishing and installing all software upgrades issued by the manufacturer during the one (1) year warranty period.

1.13 ANNUAL INSPECTION/TESTING AND SERVICE CONTRACT

A. Provide cost to furnish service, inspect, and test all devices of the fire alarm system per the requirement of NFPA for one (1) year, starting one year after the Date of Substantial Completion. Submit written reports of inspection testing per NFPA 72, Chapter 14.

B. The Owner may enter into a contract directly with the vendor after shop drawing submittals. This specification is not a contract between the Owner and the vendor to perform these services.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

A. Johnson Controls - Simplex

2.2 FIRE ALARM CONTROL PANEL (FACP)

A. Control Panel: Modular, power-limited electronic design. Provide surface wall-mounted enclosure as shown on plans. Enclosure shall be minimum 0.060 steel with provisions for electrical conduit connections into the sides and top. The door shall provide a key lock and shall include a glass or other transparent opening for viewing of all indicators.

B. Each Signaling Line Circuit (SLC loop) shall not be loaded over 80% of the maximum device capacity. For example, in the minimum system capacity column listed below, if the fire alarm manufacturer's system capacity of analog sensors per loop is 99 devices, then no more than 79 devices shall be wired on that loop. The minimum system capacity shall be as follows:

1. Minimum Total Addressable Points: 500

2. Minimum Total SLC Loops (including board, ready for field connections): 8

C. Signal Line Circuit (SLC) and Notification Appliance Circuit (NAC) Boards:

1. Each board shall communicate directly with each addressable analog sensor and binary input to determine normal, alarm, or trouble conditions. Analog signals would be used for automatic test and determination of maintenance requirements.
2. Each board shall contain its own microprocessor and shall be provided to monitor addressable inputs and to control addressable outputs (addressable relays). The board shall communicate and provide power to all devices on its loop over a single pair of wires, except where 4-wire devices require a separate power circuit.

D. Central Processing Unit:

1. The central processing unit (CPU) shall communicate with the monitor and control all other modules in the panel. Removal, disconnection or failure of any control panel module shall be detected and reported to the CPU.
2. The CPU shall execute all control-by-event programs for specific action to be taken if a designated situation is detected in the system. A real-time system clock for time annotations on the display and printer shall be included.
3. All power for the unit shall be supervised and supplied by the FAP.

E. Display:

1. The board shall provide all controls and indicators used by the system operator and may also be used to program all control panel parameters.
2. The board shall provide an alphanumeric array for display of custom alphanumeric labels for all addressable points. It shall also provide indicators for AC Power, System Alarm, System Trouble, Display Trouble and Signal Silence.
3. Displayed descriptions of addressable points shall include actual room names/numbers selected by the Owner. This information shall be obtained prior to programming. Room names/numbers shown on floor plans shall not be used.
4. The board shall provide a touch key-pad with control capability to command all system functions and entry of any alphanumeric information. Twenty different passwords with four levels of security shall be supported to prevent unauthorized manual control or programming.

F. Memory: The CPU and display interface board shall be augmented by non-volatile field programmable memory. EPROM memory will also be allowed provided the memory is burned in with minimum expansion capability equal to the total system capacity of the panel. Memory shall not be lost upon primary and secondary power failure.

G. Power Supply:

1. Input power shall be 120 VAC, 60 Hertz. Output power shall be as noted on the device specifications and drawings. Each component of the fire alarm system requiring 120 VAC input power shall be served from a dedicated life safety branch circuit. Provide two #12 conductors and one #12 ground in 3/4" conduit to a dedicated 20A/1P circuit breaker with a red handle and a manufacturer's standard handle lock-on device. Identify/label breaker and branch circuit in accordance with NFPA requirements and Specification Section 26 05 53.
2. Adequate to supply 125% of all control panel and peripheral power needs as well as 125% of power required for all external audio-visual devices. The power supply may be increased as needed by adding additional modular expansion power supplies. Over-current protections shall be provided on all power outputs.
3. All power supplies shall be designed and installed to meet UL and NFPA requirements for power-limited operation on all external initiating and indicating circuits.
4. The power supply shall provide integral charger for use with internal batteries. Battery capacity shall be sufficient for operation of the entire system for 24 hours in a non-alarm state followed by alarm mode for 15 minutes, plus 25% spare capacity for future devices.

H. Surge Protection:

1. All fire alarm control panels, NAC panels, etc. shall be provided with a surge protection device (SPD). The SPD shall be UL listed to Standard 1449 Rev 3. The unit should be clearly labeled in accordance with Identification Section 26 05 53. The SPD shall have thermal fuses to protect against fire in short circuit conditions. The unit shall provide visual indication that the unit is protecting and functioning.
2. Any communications or signaling circuits associated with the fire alarm system, which leave or enter a facility, shall be provided with a surge protection device. The devices shall be as recommended by the fire alarm system manufacturer.

I. Dual Digital Communicator:

1. Provide dual phone line interface capable of fire alarm notification to the local fire department, fire protection agency, or monitoring service. Communicator shall report in SIA and most major communication formats, with the capability of transmitting each device address point in a format compatible with the central station receiver.

J. Digitized Voice Command Center (VCC): Include integral with fire alarm system.

1. The Digitized Voice Command Center (VCC) shall contain all equipment required for all audio control, firefighter phone system control, signaling, and supervisory functions. This shall include digital voice units, speaker zone indication, firefighter phone circuit indication and control, microphones, and main firefighter phone handset.
2. Function: The Voice Command Center equipment shall perform the following functions:

   a. Operate as a supervised single channel automatic digitized voice evacuation system with manual emergency voice communication system.

3. Audio Amplifiers (AMP): Include integral with fire alarm system.

   a. The audio amplifiers will provide a single channel audio power at 25/70 volts RMS for distribution to speaker circuits.

4. Audio Message Generator (Digitized Voice):

   a. Each initiating zone or intelligent device shall interface with an emergency voice communication system capable of transmitting a digitized voice message to all speakers in the building.
   b. Actuation of any alarm initiating device shall cause a digitized message to sound over the speakers. The message shall be repeated four (4) times.
   c. A built-in microphone shall be provided to allow paging through speaker circuits.
   d. The audio message generator shall have the following controls and indicators to allow for proper operator understanding and control:

      1) All Call LED
      2) On-Line LED
      3) All Call Switch

5. Voice Messages:

   a. A pre-programmed custom digital voice message shall be used for notification appliance speaker circuits. The messages shall be approved by the Authority Having Jurisdiction (AHJ). Voice messages shall be from a female voice. The messages shall be provided in the multi-lingual language of the predominant building population.
   b. Messages shall be annunciated by a single channel in all evacuation signal zones throughout the building.

2.3 Fire Alarm Pathway Class and Survivability Level

A. Pathway Class:

1. Pathway Class B: Circuits NOT capable of transmitting an alarm beyond the location of the fault condition. Wiring of outgoing and return conductors is permitted to be run in the same conduit or cable.

B. Pathway Survivability Level:

1. Pathway Survivability Level 0: Circuits have no requirements for pathway survivability beyond the requirements of the code.

C. Interconnection of Multiple Fire Alarm Panels:

1. The pathways of interconnected fire alarm panels or systems shall be as follows:
2. Pathway Class X: Circuits with redundant pathways capable of transmitting an alarm signal during an open or a non-simultaneous single ground fault on a circuit conductor wiring system. Wiring of outgoing and return conductors shall be physically separated by a minimum of 50 feet or by a 2-hour rated enclosure.

2.4 EMERGENCY COMMUNICATION CONTROL UNIT (ECCU)

A. The ECCU shall be a listed combination system with the fire alarm system as described in NFPA 72 and meeting UL Standard 864.

B. Microphone for delivering live voice messages. Ability to interrupt public address system announcements and to silence building background music while delivering voice messages.

C. Available for use for general paging or other non-emergency messages without the activation of strobes.

D. Capacity for multiple prerecorded messages. Prerecorded messages shall be passed in the English language and also in the predominant language(s) used. Messages should address at least the following:

1. Bomb threat or actual bomb within/around the building.
2. Intruder/hostile person sighted within/around the building.
3. Occupants directed to take cover within the building.
4. Evacuation of the building using exits other than the normal main entrance/exit (since the front entrance/exit is often a location targeted by terrorists).
5. Emergency weather conditions appropriate for the local area.
6. "All Clear" message.
7. A test message intended for verifying functionality of the system.

E. Ability to automatically repeat prerecorded messages until terminated.

F. Allows the ECS to temporarily override fire alarm audible messages and provide intelligible voice commands during simultaneous fire and terrorist events. All other features of the fire alarm system, including the transmission of signals to the fire department, shall function properly.

G. Provide a supervisory signal if the ECS is used to override fire alarm audible messages during simultaneous fire and terrorist events. The supervisory signal shall be annunciated at the FACP and any remote fire alarm annunciators, and be transmitted to the fire department. The visual annunciation of the separate supervisory signal shall be distinctly labeled or otherwise clearly identified.

H. Complete set of self-diagnostics for the controller and appliance network. Local diagnostic information display, information, and system event log file.

I. Interfaces to LOC for initiating recorded messages and delivering live voice messages from locations in the building other than at the ECCU.

2.5 LOCAL OPERATING CONSOLE (EMERGENCY COMMUNICATION) (LOC)

A. Wall-mounted enclosure with tamper wire seal to minimize the potential of operation by unauthorized personnel.

B. A microphone station that emulates operation of the ECS from the ECCU.

C. Individual manual activation pushbuttons to activate the ECS prerecorded messages.

D. Provide visual notification when ECS functions have been temporarily disabled during fire and ECS events.

2.6 SIGNALING LINE CIRCUIT DEVICES

A. Combination Devices: Subscripts identify combination type devices when applicable. Contractor shall provide the combination device or provide multiple device(s) to meet the functionality when the manufacturer does not offer the required functionality with a single device.

B. Signal Line Device(s):

1. Subscripts: Subscripts are used to define the device type, installation, and identify the device with a specific sequence of operation.

a. Device type as follows:

1) W = Weatherproof
2) WG = Wire guard is required
3) Candela Ratings:

a) ## = 15 Candela, 30 Candela; 75 Candela; 110 Candela; 177 Candela
b) CD = NICET designer shall select Candela rating as required to provide full coverage of the space.

b. Sequence of operation as follows:

1) A = Atrium
2) CA = Clean Agent System
3) CR = Computer Room
4) E = Elevator Recall
5) D = HVAC Control
6) DH = Door Hold Release
7) DIPS = Dual Interlock Pre-Action System
8) FD = Fire Door Release
9) MP = Medical Procedure Room
10) S = Sleeping / Patient Room
11) SW = Stairwell

C. FA-120; Smoke Detectors:

1. Subscripts are used to define the device type, installation, and identify the device with a specific sequence of operation.

a. Device types as follows:

1) Blank = Photoelectric
2) AT = Attic (located in)
3) BR = Beam Receiver
4) BT = Beam Transmitter
5) CO = Combination Smoke / Carbon Monoxide
6) COH = Combination Smoke / Carbon Monoxide / Heat
7) COS = Combination Smoke / Carbon Monoxide / Strobe
8) H = Combination Smoke / Heat Detectors
9) ION = Ionization Type
10) ID = In-Duct Detector
11) SA = Stand Alone with Sounder
12) SB = Sounder Base
13) SV = Stand Alone with Sounder and 177 Candela Strobe

2. (BLANK) Analog Photoelectric Type Sensor: Shall use the photoelectric principle to measure smoke density and send data to the control panel representing the analog level of smoke density measured.
3. (BR) and (BT) Projected Beam Type Detectors: This device shall utilize photoelectric analog smoke sensor technology. Provide with transmitter and associated receiver. Microprocessor-based detector shall provide a minimum of eight sensitivity levels, temperature and dirt compensation, and automatic gain control. Sensor to contain beam alignment adjustments and receiver calibration.

   a. Detector shall connect directly to an SLC loop or shall be provided with multiple monitor modules, as required, to connect to the SLC loop and for monitoring alarm and trouble output contacts. The detector shall be provided complete with all mounting hardware provided and installed where indicated on the drawings.
   b. Dual alarm and power indicators shall be provided that flash under normal conditions and remain continuous under alarm or trouble conditions. Remote indicator terminals shall be provided.
   c. Provide with remote indicator panel providing LED indications of alarm and trouble.

4. (CO) Combination Smoke / Carbon Monoxide:

   a. Multi-criteria sensor for photoelectrical smoke sensing and carbon monoxide (CO) detection. Carbon monoxide electrolytic sensing module shall provide toxic gas sensing to UL2034 and UL2075 standards.
   b. The combined photoelectric smoke detection CO module shall have separate sensors that adjust the detection profile in response to the input from the sensors.
   c. The combined photoelectric smoke detection / CO module shall have selectable modes of operation for OSHA compliant toxic gas sensing, enhanced fire sensing, and nuisance alarm reduction mode.
   d. The detector shall use only one address on the SLC.
   e. CO sensor cartridge element shall be field replaceable.

5. (COH) Combination Smoke / Carbon Monoxide/Heat Detector:

   a. Multi-criteria sensor for photoelectrical smoke sensing, heat and carbon monoxide (CO) detection. Carbon monoxide electrolytic sensing module shall provide toxic gas sensing to UL2034 and UL2075 standards.
   b. The combined photoelectric smoke detection / heat / CO module shall have separate sensors that adjust the detection profile in response to the input from the sensors.
   c. The combined photoelectric smoke detection / CO module shall have selectable modes of operation for OSHA compliant toxic gas sensing, enhanced fire sensing, and nuisance alarm reduction mode.
   d. The detector shall use only one address on the SLC.
   e. CO sensor cartridge element shall be field replaceable.

6. (H) Combination Smoke / Heat Detector:

    a. Multi-criteria sensor for photoelectrical smoke sensing and rate of rise heat detection. Carbon monoxide electrolytic sensing module shall provide toxic gas sensing to UL2034 and UL2075 standards.
    b. The detector shall use only one address on the SLC

D. FA-121; Gas Detectors:

1. Subscripts are used to define the device type, installation, and identify the device with a specific sequence of operation.

    a. Device types as follows:

        1) CO = Carbon Monoxide

2. (CO) Analog Carbon Monoxide Type Sensor.

E. FA-122; Duct Smoke Detectors, Sampling Tube Type:

1. Subscripts are used to define the device type, installation, and identify the device with a specific sequence of operation.

    a. Device types as follows:
    b. Duct-type smoke detectors shall use the same analog photoelectric sensor technology, with the same features specified for standard smoke detectors, except with additional features as specified below.
    c. Provide sampling tubes and mounting hardware to match the duct to which it is attached. Where the detector housing is larger than the duct height, Contractor shall fabricate a mounting bracket for the detector and attach according to the fire alarm manufacturer's recommendations.
    d. Provide a remote alarm LED indicator device (FA-241) or (FA-242) if detector is not visible from a floor-standing position. If detector is located above a suspended ceiling, mount remote indicator in ceiling directly below detector with a white single-gang faceplate labeled: Duct Smoke Detector.

F. FA-130; Manual Pull Stations:

1. Manual pull station, addressable, double action with plastic breakrod, reset key lock, semi-flush mount, red high abuse plastic or cast metal construction with white lettering. Provided with all necessary mounting hardware. Use surface mount only on precast concrete or structure.
2. Manual stations shall connect directly to an SLC loop. Stations shall provide address setting means using rotary decimal or DIP switches.
3. Where operation is noted as required below 32°F and/or above 120°F, a conventional device shall be installed with a unique monitor module located in the nearest available location, with maintained temperatures between 32°F and 120°F.

G. FA-131; Manual Pull Stations with Cover:

1. Manual pull station, addressable, double action with plastic breakrod, reset key lock, semi-flush mount, red high abuse plastic or cast metal construction with white lettering. Provide device with clear Lexan tamper resistant cover with integral 9V battery powered alarm that sounds when shield is lifted. Provided with all necessary mounting hardware. Use surface mount only on precast concrete or structure.
2. Manual stations shall connect directly to an SLC loop. Stations shall provide address setting means using rotary decimal or DIP switches.
3. Where operation is noted as required below 32°F and/or above 120°F, a conventional device shall be installed with a unique monitor module located in the nearest available location, with maintained temperatures between 32°F and 120°F.

H. FA-140; Heat Detectors:

1. Subscripts are used to define the device type, installation, and identify the device with a specific sequence of operation.

    a. Device types as follows:

        1) Blank = Combination Rate of Rise / Fixed Temp
        2) AT = Attic (located in)
        3) F = Fixed Temp
        4) RC = Rate Compensated
        5) X = Explosion Proof

2. (BLANK) Combination rate of rise and 135°F fixed temperature analog thermal type sensor. Factory programmed to alarm at 135°F and at 15°F per minute rate-of-rise. Sensor shall measure heat level and send data to the control panel representing the analog level of thermal measurement and rate-of-rise.
3. Detectors shall be mounted, where shown on the drawings, on a twist-lock base with all mounting hardware provided.
4. Provide a remote LED indicator device if detector is not visible from a floor-standing position.
5. Dual alarm and power indicators shall be provided that flash under normal conditions and remain continuous under alarm or trouble conditions. A connection for attachment of a remote indicator shall be provided.
6. A test means shall be provided to simulate an alarm condition.
7. Where operation is noted as required below 32°F and/or above 120°F, a conventional device shall be installed with a unique monitor module located in the nearest available location with maintained temperatures between 32°F and 120°F.

I. FA-160; Monitor Modules:

1. Subscripts are used to define the device type, installation, and identify the device with a specific sequence of operation.

    a. Device types as follows:

        1) Blank = Refer to Plans
        2) KB = Knox Box Monitor

2. Monitor Module shall connect directly to an SLC loop and receive power from a separate 24 VDC circuit. It shall interface initiating devices with the control panel using Style D or Style B circuits. Contractor Option: Use an interface module (2-wire operation) for Style B circuits connected to normally-open dry contacts, such as a flow switch.
3. The module shall be mounted in an enclosure located in an accessible service location as near as possible to the device(s) being monitored, or where shown on the drawings. All mounting hardware shall be provided.
4. The module shall supply the required power to operate the monitored device(s).
5. The module shall provide address setting means using rotary decimal or DIP switches.

J. FA-161; Addressable Control Module:

1. Subscripts are used to define the device type, installation, and identify the device with a specific sequence of operation

    a. Device types as follows:

        1) Blank = Refer to Plans
        2) DH = Door Hold Open
        3) PD = Hold Open Override

2. Relay that represents an addressable control point used primarily for the control of auxiliary devices as indicated on the drawings. Contractor to provide additional child relay(s), as required, rated for the electrical load being controlled (Contractor to match voltage, amps, etc.).
3. Relay shall connect directly to an SLC loop and receive power from a separate 24 VDC circuit.
4. The relay shall be mounted in an enclosure located in an accessible service location as near as possible to the device(s) being controlled, unless otherwise shown on the drawings. All mounting hardware shall be provided.
5. The relay shall supply 24 VDC power to the device(s) being controlled, unless otherwise indicated on the drawings.

2.7 NOTIFICATION APPLIANCE DEVICES

A. Combination Devices: Subscripts identify combination type devices when applicable. Contractor shall provide the combination device or provide multiple device(s) to meet the functionality when the manufacturer does not offer the required functionality with a single device.

B. Notification Appliance Device(s):

1. Subscripts: Subscripts are used to define the device type, installation, and identify the device with a specific sequence of operation.

a. Device types as follows:

1) W = Weatherproof
2) WG = Wire guard is required
3) Candela Ratings:

a) ## = 15 Candela; 30 Candela; 75 Candela; 110 Candela; 177 Candela
b) CD = NICET designer shall select Candela rating as required to provide full coverage of the space.

b. Sequence of operation as follows:

1) S = Sleeping / Patient Room

C. Notification Device(s):

1. Wall Mounted: Red housing with white lettering or pictogram.
2. Ceiling Mounted: White housing with red lettering or pictogram.

D. FA-200; Visual Alarm Devices:

1. Wall or ceiling mounted, refer to plans.
2. High intensity (Candela rating as scheduled on the drawings) xenon strobe or equivalent under a lens. Candela rating shall be visible from exterior of the device.
3. The maximum pulse duration shall be 0.2 seconds with a maximum duty cycle of 40%. The flash rate shall be 1 Hz. Where more than two strobes are visible from any one location, the fire alarm visual devices shall be synchronized.
4. Device, housing, and backbox shall be UL listed for fire alarm/emergency applications.
5. (W) Weatherproof Visual Notification Device: High intensity strobe, square housing, 75 Candela rating, suitable for wet locations. Provide with weatherproof back box.

a. Mounting: Semi-flush wall.
b. Conduit shall not be exposed.

E. FA-220; Audio (Speaker) Alarm Devices:

1. Wall or ceiling mounted, refer to plans.

2. Sound rating shall be dependent on the tap (wattage) setting. Tap settings shall be available in 3 dBA increments. A minimum of four (4) tap settings should be available to allow field adjustment of the sound output across a minimum range of 78 to 87 dBA, 400Hz to 4KHz (6 dBA cutoff) frequency range. Speakers shall operate on a 25V RMS system, unless otherwise noted on drawings.
3. Speakers shall clearly reproduce a signal consisting of a live or prerecorded human voice and [background music] with voice intelligibility.
4. Speaker, housing, and backbox shall be UL listed for fire alarm/emergency applications.
5. Wall Mounted: Speaker, square housing, flush or semi-flush mounted.
6. Ceiling Mounted: 4" speaker, round housing, flush mounted (provide tile bridge where applicable).

F. FA-221; Combination Audio (Voice) and Visual Alarm Device:

1. Wall or ceiling mounted, refer to plans.
2. Combine speaker and visual components into a single device. Refer to the corresponding paragraphs above for requirements of each component.
3. (W) Weatherproof Voice/Visual Notification Device: Speaker with high intensity 75 Candela rated strobe. 25 VRMS with a minimum of four (4) tap settings which shall allow field adjustment of the sound output across a minimum range of 78 to 87 dBA (UL 1480), 400 Hz to 4 KHz (6dBA cutoff) frequency range.

   a. Mounting: Semi-flush wall.
   b. Conduit shall not be exposed.

G. FA-230; Emergency Combination Audio (Voice) and Visual Alarm Device:

1. Wall or ceiling mounted, refer to plans.
2. Combine speaker and visual components shall have a clear lens for fire alarm annunciation strobe and an amber lens for the alert strobe into a single device. Refer to the corresponding paragraphs above for requirements of each component.
3. (W) Weatherproof Voice/Visual Notification Device: Speaker with high intensity 75 Candela rated strobe. 25 VRMS with a minimum of four (4) tap settings which shall allow field adjustment of the sound output across a minimum range of 78 to 87 dBA (UL 1480), 400 Hz to 4 KHz (6dBA cutoff) frequency range.

   a. Mounting: Semi-flush wall.
   b. Conduit shall not be exposed.

2.8 DOOR HOLD-OPEN DEVICES

A. FA-270; Electromagnetic Door Holder Devices:

1. Flush wall mounted.
2. Voltage: 120V.
3. Holding force shall be 25 pounds minimum.
4. Provide fail-safe operation; power failure releases door.
5. Provide self-adjusting swivel catch plate with pivot points to adjust to door alignment changes.
6. Provide all hardware and wiring needed to accommodate the complete functioning door holder installation.
7. Ensure that the door hardware and trim projections are compatible with total projection of door release.
8. Provide firm anchoring for the electromagnet, such that the mounting box and device will not move independently from the wall or floor they are mounted to. This device and mounting will function as a doorstop and hold the force of the door closer mechanism.
9. Follow manufacturer's recommended installation and location instructions unless noted otherwise.
10. Electromagnetic door holder devices, housing, and back box shall be UL listed.

2.9 NOTIFICATION APPLIANCE CIRCUIT PANEL (NAC)

A. As shown on the plans or as a Contractor's option if not shown, furnish and install NAC extender panels as necessary to provide remote power supply for notification appliance circuits (NAC). Contractor shall indicate quantity and locations of each NAC on the shop drawing submittals.

B. Each NAC shall be self-contained remote power supply with batteries, and battery charger mounted in a surface lockable cabinet. Battery capacity shall be sufficient for operation for 24 hours in a non-alarm state followed by alarm for 15 minutes, plus 25% spare capacity for future devices. Each NAC provides a minimum of up to 4 outputs, 2A continuous, or 6A full load total capacity.

C. Power for each NAC shall be from a local 120 VAC emergency circuit. Provide two #12 conductors and one #12 ground in 1/2" conduit to each NAC from a dedicated 20A/1P circuit breaker with a red handle and a manufacturer's standard handle lock-on device. Coordinate panel and circuit number with the Architect/Engineer prior to installation.

D. NAC extender panels may be installed only in locations coordinated with the Architect/Engineer.

E. Mounting: Surface.

2.10 ANNUNCIATION

A. FAA; Remote LCD Annunciators:

1. Auxiliary annunciators shall indicate alarm and trouble conditions visually and audibly as shown on the drawings. Provide local TROUBLE ACKNOWLEDGE, TEST, and ALARM SILENCE capability. Minimum 80-character display.
2. Communications and power to the annunciators shall be supervised. The annunciator shall receive power from the fire alarm control panel.
3. A single key switch shall enable all switches on the annunciator.
4. Mounting: Flush.

B. FA-241; Fire Alarm Remote Indicator:

1. Red LED type.
2. Mounts flush to a single gang box.

C. FA-242; Fire Alarm Remote Indicator and Test Switch:

1. Red LED type.
2. Key switch test selector.
3. Mounts flush to a single gang box.

2.11 CONNECTIONS TO AUXILIARY DEVICES PROVIDED BY OTHERS

A. FA-250; Smoke and Fire/Smoke Damper Controller:

1. Subscripts are used to define the device type, installation, and identify the device with a specific sequence of operation.
2. Motorized type, 120 VAC, furnished and installed by MC. Fire alarm control and power connections by EC. A subscript is used to identify the device with a specific air handler or zone for its sequence of operation. Refer to the Fire Alarm Operation Matrix on the drawings and the sequence of operation descriptions in this specification section for additional requirements.
3. The EC provides:

    a. Fire alarm control and power connections by EC.
    b. Fire alarm addressable control module (FA-161) located within 5 feet of smoke damper.

c. Smoke detection, selected by NICET designer based on duct size, ventilation airflow, and specific field conditions. Detector shall be mounted within 5 feet of smoke damper. Approved options include:

1) Duct Smoke Detector (FA-122). Sampling type duct detector (FA-122) in ducts 18" and larger.

d. Remote indicator (FA-241) or Remote Indicator with test switch (FA-242) mounted in visible location. Refer to drawings for mounting location or verify location with engineer when not shown.

e. The smoke damper shall close upon activation of the detector, and a supervisory signal shall be sent to the fire alarm control panel. Refer to the Fire Alarm Operation Matrix and these specifications for complete requirements.

4. Provide an enclosure and equipment for interface of dampers with the fire alarm system and temperature control system. Refer to Detail #/### for layout, wiring and components.

B. FA-260; Flow Switch:

1. (FA-260) Connection to flow switch to monitor fire protection flow switch or discharge output contacts. Normally open dry contacts for fire alarm interface. Furnished and installed by MC; wired by EC.
2. Provide a dedicated monitor switch for each sprinkler flow switch.

C. FA-261; Tamper / Monitor Switch:

1. (FA-261) Connection to monitor switch to monitor fire protection system supervisory switches or output contacts. Normally open dry contacts for fire alarm interface. Furnished and installed by MC; wired by EC.
2. Tamper switches in the same room or system may be monitored by a single monitor switch when shown grouped on the plans.
3. Subscripts: Subscripts are used to define the device type, installation, and identify the device with a specific sequence of operation.
4. Device types as follows:

a. Blank = Refer to Plans
b. PIV = Post Indicator Valve

5. (PIV) Post Indicator Valve. Connection to post indicator valve for sprinkler system supervisory notification. Normally open dry contacts for fire alarm interface. Furnished and installed by MC; wired by EC. Provide surge protection device as recommended by the fire alarm system manufacturer on line entering/leaving the facility.

D. FA-263; Electronic Bell:

1. Electronic bell for sprinkler alarm, electro-mechanical type, 120 VAC. Furnished and installed by MC. Fire alarm control and power connections by EC.

E. FA-161; Lighting Control Override:

1. Subscript: Subscripts are used to define the device type, installation, and identify the device with a specific sequence of operation.

a. LC = Lighting Control Override

2. The lighting control system(s) is equipped with a remote input fire alarm override contact to allow the fire alarm system via an output relay to override the lighting control sequence of operation upon a fire alarm "alarm" condition. The fire alarm system will provide addressable fire alarm output relay(s) to interface with the lighting control system. Coordinate the location and quantity of relays required with the lighting control system.

3. Provide (FA-161) fire alarm addressable control module for each interface required for the lighting control system.

2.12 WIRING

A. Fire alarm wiring/cabling shall be furnished and installed by the Contractor in accordance with the manufacturer's recommendations and pursuant to National Fire Codes. Cabling shall be UL listed and labeled as complying with the Electrical Code for power-limited fire alarm signal service.

B. Fire Alarm Cable:

1. Manufacturers:

a. Comtran Corp.
b. Helix/HiTemp Cables, Inc.
c. Rockbestos-Suprenant Cable Corp.
d. West Penn Wire/CDT.
e. Radix.

PART 3 - EXECUTION

3.1 SEQUENCES OF FIRE ALARM OPERATION

A. General:

1. Refer to the Fire Alarm Operation Matrix on the drawings for basic requirements and system operation.
2. All system output programs assigned via control-by-event equations to be activated by the particular point in alarm shall be executed, and the associated system outputs (alarm notification appliances and/or relays) shall be activated.

B. Panel/Annunciator Alarm, Trouble, Supervisory Indication:

1. Appropriate system Alarm, Trouble, or Supervisory LED shall flash at the control panel, transponder, and annunciator locations.
2. A local signal in the control panel shall sound.
3. The LCD display shall indicate all information associated with the condition, including the name of the item, type of device and its location within the protected premises.
4. Printing and history storage equipment shall log the information associated with the fire alarm control panel (FAP) condition, along with the time and date.
5. Transmit the appropriate signal (supervisory, trouble, alarm) to the central station via the digital communicator.
6. Transmit the appropriate signal (supervisory, trouble, alarm) to the building automation system via addressable relays tied to contact monitors on the system.

C. Audible Alarms Sequence:

1. Audible alarms throughout the building shall sound.
2. Separate voice announcements shall be played in different fire compartments depending on proximity to the device that initiated the alarm. Refer to the requirements above for the Voice Command Center programming.

D. Visual Alarms Sequence:

1. Visual alarms throughout the building shall flash.

E. Fire Protection Electric Sprinkler Bell Sequence:

1. The fire alarm shall utilize an addressable relay to energize the electric sprinkler bell upon activation of the flow switch.

F. Smoke Damper Control Sequence:

1. The fire alarm system shall utilize an addressable relay to open the power connection to smoke or fire/smoke dampers and allow them to close. Coordinate other requirements with damper installer.
2. Where a damper is in a main air duct, where closure of that single damper will entirely block airflow in the duct system, the smoke damper sequence shall also initiate the AHU and mechanical fan shutdown sequence for the affected unit.
3. The AHU and mechanical fan shutdown sequence shall be initiated only when ALL the dampers associated with that unit or mechanical fan are closed. Otherwise, the AHU or mechanical fan shall continue to serve other areas.

G. AHU and Mechanical Fan Shutdown Sequence:

1. The fire alarm system shall utilize addressable relays to de-energize all AHU motor controllers and mechanical fans. Coordinate other requirements with HVAC installer.
2. The fire alarm system shall directly shut down the AHU or mechanical fan through the local HVAC control device (i.e., variable frequency drive or motor starter).
3. Where a facility has more than one AHU or mechanical fan, each shall be shutdown individually based on input from initiation devices in the area served by the unit or designated for each air distribution system.

H. Door Holder Release Sequence:

1. The fire alarm system shall utilize an addressable relay to open the power connection to integral and magnetic door holders.
2. The fire alarm system shall utilize an addressable relay to open the 'hold' switch circuitry, integral to the power door.
3. Door holders shall release individually based on initiation devices in the vicinity of the door and noted specifically for door closure.

I. Elevator Recall Sequence:

1. Elevator recall sequences shall meet the requirements of ASME/ANSI A17.1 and NFPA 72.
2. Upon signal from a smoke detector in the machine room, hoistway, or any elevator lobby other than the "designated level" the fire alarm shall utilize an addressable relay to signal the elevator to recall to the designated level as determined by the Authority Having Jurisdiction.
3. Upon signal from a smoke detector in the elevator lobby of the "designated level," the fire alarm system shall utilize an addressable relay to signal the elevator to recall to the "alternate level" as determined by the Authority Having Jurisdiction.
4. All elevators that share the same hoistway, machine room or lobby shall be recalled simultaneously. Elevators served by different machine rooms, hoistways and lobbies shall continue to operate.

J. Firefighter's Cab Visual Alarm Sequence:

1. Upon signal from a detector in the machine room or elevator hoistway, the fire alarm system shall utilize an addressable relay to signal the elevator controller to illuminate and flash the firefighters cab visual alarm.

K. Elevator Shutdown Sequence:

1. Elevator shutdown shall meet the requirements of ASME/ANSI A17.1.
2. All elevators that share the same hoistway, machine room, or lobby shall be shut down simultaneously. Elevators served by different machine rooms, hoistways, and lobbies shall continue to operate.

3. The fire alarm system shall utilize an addressable relay to energize the shunt trip of the main elevator breaker, disconnecting power to the elevator.

L. Lighting Control Override Sequence: Coordinate requirements between the fire alarm and lighting control system.

1. The fire alarm shall use addressable output relay(s) to remotely override the local lighting control sequences of operation for egress, emergency, and life safety designated lighting. Coordinate the location and quantity of addressable output relays required with the lighting control shop drawings. Addressable fire alarm relays will be required, but not limited to, at the following locations:

a. Branch circuit lighting control zones, relays, automatic load control relays (ACLR), branch circuit emergency lighting transfer switches (BCELTS).

M. Access Control Override Sequence:

1. The fire alarm shall use addressable output relay(s) to signal the access control panel.
2. Refer to the access control specifications for requirement upon fire alarm signal. The fire alarm shall initiate an override of delayed egress doors.

3.2 INSTALLATION

A. Install system in accordance with manufacturer's instructions and referenced codes.

B. Fire Alarm Control Panel:

1. Install the control panel where shown on the drawings.
2. All expansion compartments, if required, shall be located at the control panel.
3. The fire alarm voice prerecorded messages shall be verified by the Contractor, as approved by the Owner, prior to the shop drawing submittal process.

C. Devices:

1. General:

a. All ceiling-mounted devices shall be located where shown on the reflected ceiling and floor plans. If not shown on the reflected ceiling or reflected floor drawings, the devices shall be installed in the relative locations shown on the floor drawings in a neat and uniform pattern.
b. All devices shall be coordinated with luminaires, diffusers, sprinkler heads, piping and other obstructions to maintain a neat and operable installation. Mounting locations and spacing shall not exceed the requirements of NFPA 72.
c. Where the devices are to be installed in a grid type ceiling system, the detectors shall be centered in the ceiling tile.
d. The location of all fire alarm devices shall be coordinated with other devices mounted in the proximity. Where a conflict arises with other items or with architectural elements that will not allow the device to be mounted at the location or height shown, the Contractor shall adjust location of device so that new location meets all requirements in NFPA 72 and all applicable building codes.

2. Per the requirements of NFPA, detector heads shall not be installed until after the final construction cleaning unless required by the local Authority Having Jurisdiction (AHJ). If detector heads must be installed prior to final cleaning (for partial occupancy, to monitor finished areas or as otherwise required by the AHJ), they shall not be installed until after the fire alarm panel is installed, with wires terminated, ready for operation. Any detector head installed prior to the final construction cleaning shall be removed and cleaned prior to closeout.

3. Protection of Fire Alarm System:

   a. A smoke detector shall be installed within the vicinity of the main fire alarm panel and every NAC extender panel per NFPA 72. A heat detector may be substituted when a smoke detector is not appropriate for the environment of installation.

4. Analog Smoke and Heat Detectors:

   a. In elevator shafts and elevator equipment rooms, provide a heat detector for elevator shutdown within 2' of every sprinkler head. Coordinate with fire protection contractor.

5. Duct-type Analog Smoke Detectors:

   a. Duct-type analog smoke detectors shall be installed on the duct where shown on the drawings and details. The sampling tubes shall be installed in the respective duct at the approximate location where shown on the electrical drawings to meet the operation requirements of the system.
   b. All detectors shall be accessible.
   c. Duct-type detectors shall be installed according to the manufacturer's instructions.

6. Manual Pull Stations:

   a. Stations shall be located where shown and at the height noted on the drawings.

7. Addressable Relays and Monitor Modules:

   a. Modules shall be located as near to the respective monitor or control devices as possible, unless otherwise indicated on the drawings.
   b. All modules shall be mounted in or on a junction box in an accessible location.
   c. Where not visible from a floor standing position, a remote indicator shall be installed to allow inspection of the device status from a local floor standing location.

8. SLC Loop Isolation Modules:

   a. Isolation modules shall be installed to limit the number of addressable devices that are incapacitated by a circuit fault.
   b. Install all Isolation Modules within the fire alarm control panel, unless otherwise indicated on the drawings. Refer to the fire alarm riser diagram for requirements. Refer to the floor plans for areas served by separate isolation modules.

9. Notification Appliance Devices:

   a. Devices shall be located where shown on the drawings.
   b. Wall-mounted audio, visual and audio/visual alarm devices shall be mounted as denoted on the drawings.
   c. Where ceiling mounted visual alarm devices or combination audio/visual alarm devices are shown where the ceiling is greater than 30'-0" high, they shall be stem mounted so that the entire unit is below 30'-0". This does not apply to audio-only alarm devices.

D. Wiring:

1. Fire alarm wiring/cabling shall be provided by the Contractor in accordance with the manufacturer's recommendations and pursuant to National Fire Codes.
2.
3. Wiring shall be installed in conduit from device to above accessible ceilings. Exposed plenum-rated cable (FPLP) shall be used above accessible ceilings supported every 4 feet or run in cable trays (if applicable) maintaining a minimum of 5-inches clearance from all lighting ballasts. Fire alarm cabling shall not be installed in the same bridle rings or cable trays designated for the cabling of other systems.

4. All junction boxes with SLC and NAC circuits shall be identified on cover. Refer to Identification Section 26 05 13 for color and identification requirements.
5. Fire Alarm Power Branch Circuits: Building wiring as specified in Section 26 05 13.
6. Notification Appliance Circuits shall provide the features listed below. These requirements may require separate circuits for visual and audible devices.

    a. Fire alarm temporal audible notification for all audio appliances.
    b. Synchronization of all visual devices where two or more devices are visible from the same location.
    c. Ability to silence audible alarm while maintaining visual device operation.

7. Notification Appliance Circuits shall not span floors or smoke compartments. Refer to architectural drawings for smoke compartments.
8. Signal line circuits connecting devices shall not span floors or 2-hour smoke compartments.
9. No wiring other than that directly associated with fire alarm detection, alarm or auxiliary fire protection functions shall be in fire alarm conduits. Wiring splices shall be avoided to the extent possible, and if needed, they shall be made only in junction boxes, and enclosed by plastic wire nut type connectors. Transposing or changing color coding of wires shall not be permitted. All conductors in conduit containing more than one wire shall be labeled on each end, in all junction boxes, and at each device with "E-Z Markers" or equivalent. Conductors in cabinets shall be carefully formed and harnessed so that each drops off directly opposite to its terminal. Cabinet terminals shall be numbered and coded, and no unterminated conductors are permitted in cabinets or control panels. All controls, function switches, etc. shall be clearly labeled on all equipment panels.

E. Fire Alarm Cabling Color Code: Provide circuit conductors with insulation color coding as follows, or using colored tape at each conductor termination and in each junction box.

    1. Power Branch Circuit Conductors: In accordance with Section 26 05 53.
    2. Signaling Line Circuit: Overall red jacket with black and red conductors.
    3. DC Power Supply Circuit: Overall red jacket with violet and brown conductors.
    4. Notification Appliance Circuit: Overall red jacket with blue and white conductors.
    5. Door Release Circuit: Gray conductors.
    6. Central Station Trip Circuit: Orange conductors.
    7. Central Station Fire Alarm Loop: Black and white conductors.

F. Devices surface mounted in finished areas shall be mounted on surface backboxes furnished by fire alarm equipment supplier. Backboxes shall be painted to match device, shall be the same shape and size as the device shall not have visible knockouts.

G. Make conduit and wiring connections to door release devices, sprinkler flow and pressure switches, sprinkler valve monitor switches, fire suppression system control panels, duct analog smoke detectors and all other system devices shown or noted on the Contract Documents or required in the manufacturer's product data and shop drawings.

3.3 FIELD QUALITY CONTROL

A. Field inspection and testing will be performed under provisions of Section 26 05 00.

B. Test in accordance with NFPA 72, Chapter 14 and local fire department requirements. Submit documentation with O & M manuals in accordance with Section 14.6 of the Code.

C. Contractor shall test and adjust the fire alarm system as follows:

    1. Speaker taps shall be adjusted to the lowest tap setting which achieves a sound level higher than or equal to the greatest of the following:

        a. 70dBA.
        b. 15 dBA above ambient levels as indicated in NFPA 72 Table A.18.4.3.

c. 15 dBA above measured ambient. 5 dBA above the maximum measured sound level with duration of more than 60 seconds.

2. Sound level measurement procedure shall meet the following requirements:

a. All measurements shall use the 'A' weighted, dBA, sound measurement scale.
b. All measurements shall be taken after furnishings, wall coverings and floor coverings are in place.
c. All measurements shall be taken after fixed equipment (HVAC units, etc.) producing ambient noise is installed and is in operation.
d. Final ambient sound measurements shall be taken during occupancy and the units shall be re-adjusted at that time, if necessary.
e. All sound level measurements shall be taken at a height of 5' above the finished floor level.
f. Measurements shall be taken in every unique room. If there are multiple rooms, which have the identical dimensions and function, 10%, or a minimum of two (2) rooms shall be tested. The results from the rooms tested shall be averaged and the remaining rooms may be adjusted per the average.
g. Measurements shall be taken on a 20' x 20' grid and the results for all points taken shall be averaged. If the room is smaller than 20' x 20' a minimum of two measurements are required.
h. Measurements shall be taken halfway between speakers or halfway between a speaker and the wall. No measurements shall be taken at the extreme edges of the room, nor directly under speakers.

D. Additionally, test the voice alarm communication system intelligibility per IEC 60849:

1. The following acoustically distinguishable spaces shall be tested: All unique rooms shall be tested. If there are multiple rooms with the identical dimensions and function, 10%, or a minimum of two (2) rooms, shall be tested. The results from the rooms tested shall be averaged, and the remaining rooms may be adjusted per the average.
2. Utilize equipment designed to test per IEC 60849 per the equipment manufacturer's instructions. This equipment includes a signal generator, which is input to the fire alarm system and a portable measurement device. This equipment is available from Simplex Grinnell or Gold Line.
3. Testing equipment that can simulate 'crowd babble' shall be used in rooms with occupancy of greater than 200.
4. Wide-area notification intelligibility shall be tested in acoustically distinguishable spaces and areas as designated by the Owner.
5. When testing for intelligibility, the quantity and location of the measurement points shall be the same as the points used for measurement of dBA level.
6. Provide a room by room report, showing the average dBA level and STI for each room tested, the number and location of. The report shall be presented to the Architect/Engineer in an Excel .xls file.

3.4 MANUFACTURER'S FIELD SERVICES

A. Provide manufacturer's field services under provisions of Section 26 05 00.

B. Include services of certified technician to supervise installation, adjustments, final connections, and system testing.

C. Note that room numbers depicted on the architectural/engineering drawings will not necessarily reflect the actual room (signage) numbers that the Owner selects. Contractor and fire alarm manufacturer shall coordinate the actual room numbers as the Owner directs to identify each device. This list shall be a part of the floor plan record drawing to be turned in at the project closeout.

D. Include the services to train up to three of the Owner's staff in operation, maintenance, and programming of the fire alarm system at the manufacturer's factory. Airfare and lodging expenses for the Owner's staff will be by the Owner.

E. System Occupancy Adjustments: When requested by Owner within 12 months of date of Substantial Completion, provide on-site system adjustments to suit actual occupied conditions. For this purpose, provide up to two (2) site visits, four (4) hours each visit, outside normal occupancy hours.

3.5 SYSTEM TRAINING

A. System training shall be performed under provisions of Section 26 05 00.

B. Minimum on-site training times shall be:

1. System Operators: One (1) day.
2. Emergency Communication System: Four (4) hours.

END OF SECTION 28 31 00

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